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STUDIES ON POLY VINYL CHLORIDE FLOORINE

A MAJOR PROJECT SUBMITTED TO THE
UNIVERSITY OF DELHI
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR
THE AWARD OF THE DEGREE OF

MASTER OF ENGINEERING
IN
POLYMER TECHNOLOGY

BY
AVDESH KUMAR

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July - 2000

STUDIES
ON
POLY VINYL CHLORIDE
FLOORING

CERTIFICATE

*This is to certify that Mr Avdesh Kumar M E (Polymer Technology) Student Delhi College of Engineering has satisfactorily completed his major project entitled "**Studies on POLYVINYL CHLORIDE FLOORING**" in partial fulfilment for the award of the Master of Engineering in Polymer Technology of University of Delhi This thesis is an original work which has not been submitted to any other institute, university or organization for the award of any degree or diploma to the best of our knowledge*

I wish him all the best success in life

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Chemistry [illegible] neering
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TO WHOM SOEVER IT MAY CONCERN

This is to certify that Mr. Avdhesh Kumar S/o Sh. J.P. Sharma, a student of M.E. (Polymer Technology) of Delhi College of Engineering, Delhi has undergone in Plant Training with us for a period of 5 months commencing from 07.07.99 to 06.12.99.

During this period of training, he was exposed to major project work and other related field of R&D activities.

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*Finally, I record with sincere gratitude the blessings of my parents Smt Raj Bala Sharma, **Late Jagdish Prasad Sharma** and brothers The moral support from my wife Smt Kalpana Sharma*

(AVDESH KUMAR)

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INTRODUCTION

Plastic are most wonderful substance and constitute a very important contribution of chemistry to the well being of mankind Plastics are so much a part of our lives, that it is difficult to imagine getting through a day without them it is been so years since plastic first began to be used

Commercially Plastic can be super tough, rigid or flexible transparent as well as opaque and can be allow selective permeation or act as a barrier They can be insulators or can be made conductive Plastic are not only replacing materials such as metal and wood but have also created new opportunities to mass product consumer items that never be made economically better before the ease with which plastic can be processed in to a varity of articles of everyday life small and big is truly remarkable and has no parallels Plastic are so versatile and easy to fabricate in varity of forms that their uses are unlimited

GROUP PROFILE

PREMIER POLYFILM LIMITED

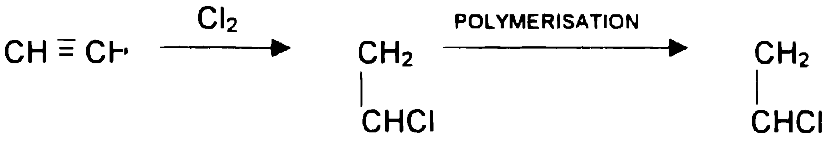
Premier range of products of polymer films sheeting and flooring artificial leather cloth is aviable at "premier polyfilm limited" belongs to premier group of companies in India the popular brand name of premier polyfilm product is **"Polyfloor"** in a very short span of time of two year premier polyfilm is not only one of leading companies but it has also spread its wings vary wall to the rest of the world as one of the largest manufacture and exporters of P V C films sheeting and flooring in India

Premier films are marketed in over 20 countries world wide our strength lies in providing consistent high quality productsbacked up by our experienced and enthusiastic team of technical and marketing staff who are dedicated to meetingcoustomer needs in today highly advanced and competative environment

RAW MATERIALS

The world of polymers consists of a large number of families such as Vinyls Olefins, Fibers, Wax, Cellulose etc PVC is the most important member of large family of polymer reffered as VINYLS The important member of vinyl family of polymer are PVC homopolymers, PVC copolymers

Polyvinylidene chloride, we mainly consider PVC homopolymers, PVC homopolymers are manufactured by there types of polymerisation process these processes are suspension emulsion and mass (or bulk) process mainly PVC polymers are produced by suspension polymerisation PVC resin so produced is generally sold as flowing powder or as a compound or as Latex



$$CH \equiv CH \xrightarrow{Cl_2} \begin{array}{l} CH_2 \\ | \\ CHCl \end{array} \xrightarrow{\text{POLYMERISATION}} \begin{array}{l} CH_2 \\ | \\ CHCl \end{array}$$

PVC resin by itself is not a commercially useful polymer and to achieve process ability and optimum performance characteristics various compounding

additives must be added these additives can be classified as Stablizers Plasticisers, Lubricants, Fillers impact modifiers, processing aids colourents and other miscellaneous ingradients

PVC compounds can be broadly classified as rigid and flexable all PVC compoumds so not contain all the groups of compounding additives for e g rigid compounds contain no plasticisers flexable compounds contain no impact modifiers and transparent compounds contain no fillers

DETAILS OF INGRADIENTS USED IN COMPOUNDING OF PVC

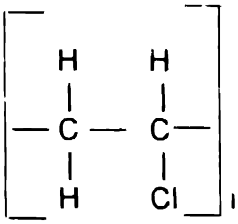
1 RESIN -

PVC suspension resin is a major constituent in any formulation defferent grades of PVC resin are characterised by their M W generally the M W of P V C is expressed commonly as K value Proper selection of resin depends upon desired processability and end use requirment

PVC HOMOPOLYMERS

(a) Chemical Structure -

The basic repeat unit of the PVC polymer chain is



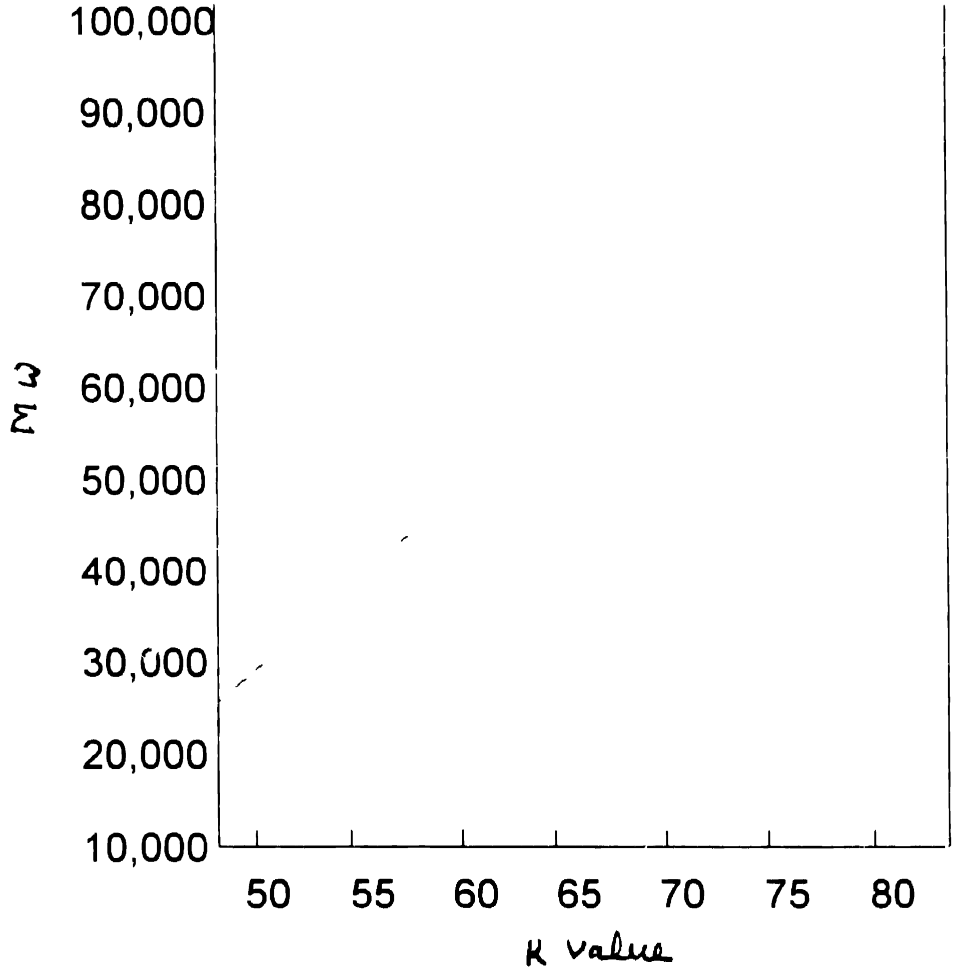
$$\left[-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle Cl}{C}}-\right]_l$$

Where l is the degree of polymerisation, i e the number of repeat units in the molecular chain The units are linked virtually exclusively `head to tail` i e

$-CH_2-CHCl-CH_2-CHCl-$

In commercial PVC polymers the average value of n range between about 500 and 1500 this correspondence to a theoretical molecular weight range to about 31000-94000

Most commercial PVC polymers have K value within the range 50-80 equivalent to about 50000-500000 Mw and 30000-90000 Mn The ralationship is illustrated in fig Polymers of much higher molecular weight have also been made like those of other thermoplastics the properties of PVC polymer are influenced by both the molecular weight and molecular weight distribution ,



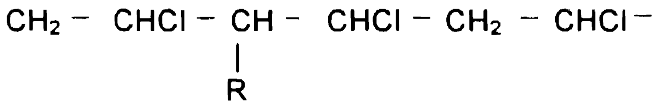
(Relation between Molecular Weight and the K value of P V C polymers)

The polymerisation temperature influences the molecular weight, and hence the dilute solution viscosity, of PVC polymer this factor was examined by rgvey and waterman for the polymerisation temperature range 0-70 ^0C Intansive heating may be necessary to ensure complete dissolution of PVC polymers produced at sub-zero temperature for solution viscosity measurement and determination of Mw by light scattering and gel-permeation chromatography

The structure of PVC polymer molecules deviate in practice from the theoretical ideas of linar chains of $- CH_2 - CHCl -$ units terminating in $- CH_2 CH_2Cl$ and $-CHCl - CH_3$ groups The main difference are listed below

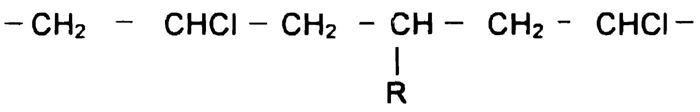
CHAIN BRANCHING

The chains of commercial PVC polymers are branched Estimates of the extented of branching based on determination by various techniques range from 0 5 to 20 branches per 1000 carbon atoms, and include the suggestion that 5 out of every 1000 carbons are mithyl-branched whilst up to 2 per 1000 carry side-chains of more than 5 carbon atoms The two most probable structures for a branch junction are believed to be



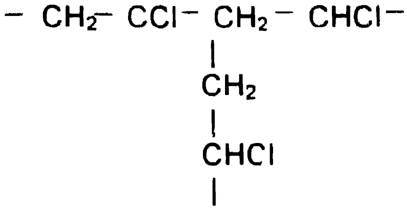
$$CH_2 - CHCl - \underset{\overset{|}{R}}{CH} - CHCl - CH_2 - CHCl -$$

And



$$- CH_2 - CHCl - CH_2 - \underset{\overset{|}{R}}{CH} - CH_2 - CHCl -$$

Where the side-chain R is $-CH_2-$ $CHCl$ −or CH_3 the presence in PVC polymers of branch junctions involving the existence of a tertiary chlorine



$$-CH_2-CCl-\underset{\underset{\underset{|}{CHCl}}{\underset{|}{CH_2}}}{\underset{|}{CH_2}}-CHCl-$$

has been the subject of much speculation as their formation (by appropriate radical transfer to polymer in the course of polymerisation) is a valid theoretical possibility whilst-if present-they would constitute important sites for initiation of thermal or photo degradation of the polymer However no direct evidence of the presence of tertiary Cl, or of any functional relationship between the number of chain branched and thermal stability

END-GROUPS

A large variety of end-groups is encountered in commercial PVC polymer Some are acquired by reaction in the course of polymerisation with fragments of initiators emulsifying or suspending agents or other external compounds present (to which chain transfer can occure) Other are formed in terminating reactions involving the monomer and/or any of the species generating during polymerisation Example of the end-groups originating in the former way are

$-CH_2-OC-C_6H_5$, $-CH_2-O-SO_2-$ OR , and $-CH_2OH$

(Where R is an alkyl radical) those formed in the internal terminating reactions are $-CHCl-CH=CH_2$ (an allyl chloride type of structure in which the Cl atom is activated by the unsaturated linkage at the 3,4 position relative to it)

$- CH = CHCl$, $- CCl = CH_2$, $- CH_2 - CH_2Cl$, $- CHCl - CH_2Cl$, and
$- CH_2 - CH_2Cl$

OTHER STRUCTURAL FEATURE:-

The result of several studies confirm the presence of double bonds distributed randomly in the polymer chain ordinary PVC polymer may contain up to 15 such bonds per 1000 carbon atoms Some evidence has also been obtained of the presence of oxygen,apart from oxygen containing end-groups some oxygen could be incorporated in the chain during polymerisation,or acquired through oxidation of the polymer, however the resulting chemical grouping have not been indentified

MORPHOLOGY

Commercial PVC polymers may be regarded as essentially amorphous, although crystalline material contents of about 2-10% have been reported on the basis of determination by X ray diffraction methods, thermal analysis (DTA DSC TMA) and density measurment The crystallinity is associated with the stereoregular polymer fraction

The glass transition temperature (Tg) of commercial homopolymers lie in the range 80-84°C Anncaling above the Tg increases crystallinity and also the crystalline meking temperature (as given by the endothermic peak on DTA curves) The density of the crystalline fraction has been reported as 1530 kgs m^{-3} and that of totally amorphous polymer as 1337 kg m^{-3}

As would be expected anneling below the Tg has no effect on crystallinity however it can increase the density this has been attributed to a reduction of the free volume in the polymer without ordering of its fine structure Apparently the kind of short range non- crystalline order which can develop in some essentially glassy but partly crystallisable polymers on heating below the Tg does not arise in PVC

Relatively highly crystalline PVC polymer with high syndiotactic material content have also been prepared (by polymerisation at low temperature or in certain solvent) The preparation of fibers and film from such polymer has been reported as well as that of plasticised compoundes The melting point of the crystalline polymer can be as high as 265-273°C (if commercial PVC polymer about 210°C in the absence of decomposition) The above mentioned plasticised compounds of crystalline PVC had higher modulus and hardness and lower tensile creep at room temperature than a similar compound of ordinary commercial PVC polymer (but lower tensile strength and extension at break) below –25°C the modulus and hardness were lower (i e the flexbility greater) than those of the normal PVC

Molecular orientation of the PVC polymer and the associated structural anisotropy, can be an important factor in the morphology of PVC product (especially uPVC) Thus in PVC mouldings the skin and core effect (a well known common feature also of other polymer mouldings) can involve `inter alia a considerable degree of orientation in the skin

Biaxial orientation of the polymer in PVC bottels films and thermoformed articles increases impact resistance and reduces permeability The tensile strength

and retraction on heating of extruded products is strongly influenced by longitudinal molecular orientation imparted by stretching in production whilst the high degree of orientation produced in PVC fibers by the drawing process in manufacture is responsible for their very high tensile strength in comparisation with other PVC products The fracture and yield behaviour of PVC polymer and uPVC composition is strongly influenced by the extent and nature of molecular orientation Useful investigational work in these areas has been reported by several authors

VINYL CHLORIDE COPOLYMER

Some of these are long established commercial materials others more recent have also become of more than academic interest The oldest and still most widely used are vinyl chloride copolymer

In most of the vinyl chloride copolymer of commercial interest the co-monomer units are in a minor proportion (and randomly distributed) in the polymer chain, i e most are internal, random copolymers, with the VC units predominating copolymer with vinylidene chloride (VC/VDC) are a notable partial exception here, in that whilst those used in certain PVC composition

Copolymer are normally more readily soluble than homopolymers when used as surface coating they adhere better to many substrates (the adhesion may be further improved by the incorporation of a suitable third comonomer in the chain)

Broadly speaking the morphology of most copolymers is similar to that of PVC homopolymer except that the reduced regularity of the chain is an extra hindrance to crystallisation The chain in structure of PVDC is favourable to

Ethylene route (Balanced process)

$$CH_2 = CH_2 \longrightarrow CH_2Cl - CH_2Cl \longrightarrow CH_2 = CHCl + HCl$$

Acetylene route

$$CH = CH + HCl \xrightarrow{\text{catalyte}} CH_2 = CHCl$$

$$2CH_2 = CH_2 + 4HCl + O_2 \longrightarrow 2CH_2Cl - CH_2Cl + H_2O$$

Main reaction routes in industrial production of P V C

The balanced process embodiment of the ethylene route long favoured in the USA has provided the basis of industrial production of vinyl chloride in most of the major plants set up since the mid 1960s, in which petrolium derivrd ethylene is used

VCM (Vinyl chloride monomer) is a colourless gas at room temperature and normal pressure, with explosive limits of about 4-20% by volume in air For industrial processing it is normally kept as a liquid under pressure It has anaesthetic properties and an odour resembling that of chloroethane

The polymerisation techniques used to produce PVC polymer are in order of commercial importance, suspension polymerisation (about 80% of total commercial polymer production), emulsion polymerisation bulk polymerisation also called mass polymerisation and solution polymerisation

The commercial application of the solution process is almost entirely confined to the manufacture of copolymers for use in surface coatings Polymerisation is carried out in a liquid which may either be a solvent for both the monomer(s) and the polymer or only for the monomer(s) so that the forming polymer precipitates out of the system This can also happen in initially homogeneous system above a certain degree of conversion Initiators and selected chain transfer agents are included in a tycial solution polymerisation system The resulting polymers can be of high purity and the method affords good control over molecular weight

In a typical suspension polymerisation process a suspension of monomer droplets (about 50-150 um) in water is formed by vigorous agitation in a pressure vessel and the monomer of the droplets, which contain a monomer soluble free radical initiators,is polymerised at a slightly elevated temperature under the autogenous VCM vapour pressure corresponding to the reaction temperature Protective colloids are included in the aqueous phase to stabilise the suspention throughout, and also buffers to countract developmentof activity When 80-90% of the monomer has been converted to polymer the reaction is stopped by venting off excess monomer from the reactor The resulting slurry of polymer in water is freed from the remaining monomer by further evaporation either in the autoclave itself or in a separate vessel This process is known as stripping to secure effective high degree of removal of residual VCM stripping is assisted and completed by steam sparging different variants both batch-wise and continious of this operation exist All essentially involving scrubbing the slurry with steam at an elevated temperature

continuous, counterflow scrubbing in an efficient column can reduce the VCM content of the polymer to below 1ppm The stripped slurry is centrifuged to remove free water and the resulting wet polymer cake is dried by hot air

The bulk polymerisation system comprises only the monomer and a free radical initiator Polymerisation is carried out under pressure and normally at 40 70 °C The process has two distinct stages first polymer grain from in and seprate from the liquid VCM phase (unlike some other polymers polyvinyl chloride is insoluble in its monomer), giving rise to a heterogeneous system This stage is carried out under strong agitation to ensure uniformity and correct morphology of the grains At a relatively low degree of conversion much of the VCM liquid is absorbed onto the porous polymer grains and the viscosity, initially low in the essentially liquid system become too high for effective stirring whereas the grains develop enough strength to withstand transfer to a second stage reactor second stage are introduced during the transfer At about 20% conversion the material has the appearance and consistency of damp powder and that of a dry powder at about 40% conversion Agitation particularly important in the second stage is provided by agitators,of special design Polymerisation is terminated at a predeterminded level of conversion by venting off unreacted VCM Residual monomer is stripped from the polymer by de-gassing assisted by interoduction of steam or an inter gas to act as carrier

In emulsion polymerisation the system consists of the monomer and water containing emulsifier(s) and a water-soluble initiators In designed for operation at the VCM vapour pressure generated at the reaction temperature, say up to about 1

Mpa In the presence of the emulsifier(s), agitation of the charge in the autoclavedisperses the monomer into very fine droplets The initiator (commonly potassium or ammonium persulphate alone or with a reducing agent or a more complex redox system) produces free radicals in the monomer phase The degree of conversion is normally about 90% the reaction being terminated by venting off excess monomer The final stripping of VCM from polymer produced by the emulsion process is similar in principal to that practised some spraying methods have been claimed to be particularly effective Continuous emulsion polymerisation process are also operated by a few companies Indeed this type of process was among the earliest industrial PVC resin production process to be developed

In principal subject to suitability of co-monomer reactivities, all the four types of polymerisation process mentioned may be used for the production of vinyl chloride copolymer In the case of bulk polymerisation it is also necessary that the copolymer should be insoluble in their monomer In practice, the most important commercial copolymer- vinyl chloride/acetate- is normally produced by suspension polymerisation for melt processing and by the solution process for surface coating applications

POLYMER CHARACTERISTIC CARDINAL TO BEHAVIOUR IN PROCESSING AND/OR SERVICE PERFORMANCE

The features defining the principal difference among PVC polymer and mainly responciblefor their service properties and/or processebility are

1 chemical composition (i e whether homopolymer or copolymer and-in copolymers- the chemical nature and proportion of comonomer present)

2 molecular weight (average and distribution)

3 particle characteristic (size and size distribution, morphology)

The nature and amounts of extraneous impurities and adventitious functional groups in the polymer chains are also significant in some contexts

COMPOSITION

In the commercial sence the most imporatnt copolymer of vinyl chloride are those with vinyl acetate The incorporation of this co-monomer into the polymerchain reduces the melt viscosity and improves solubility(a desirable feature in some solution applications) but the softning point, heat stability and toughness are also reduced For copolymer of comparable molecular weight these effect increase with increasing proportion of the vinyl acetate components This proportion is in the range to 10-16% in copolymers for both melt and solution processing, although in solution polymers modified with a third componant the vinyl acetate content may be as low as 2%of the three main melt processing outlet for VC/VA copolymer, flooring (where case of melt flow, and ability to accept large amounts of fillers are important) and gramophone records (again requiring good flow, and faithful reproduction of moulding surface detail) call for polymer of high vinyl acetate content and low molecular weight On the other hand for packaging films and foils, where easy melt flow must be combined with good melt elasticity, and good mechanical properties are required in the product, a typical choice would be copolymer of about 60 K value containing about 10% vinyl acetate

In commercial copolymer of vinyl chloride with ethylene and propylene , the presence of the olefin component affect the melt viscosity in the same way as that

of the vinyl acetate in VC/VA copolymer However there is comparatively very little adverse effect on heat stability and strength properties

Nevertheless the use of these copolymers is very limited mainly because they are considerable more expensive than VC/VA copolymers

MOLECULAR WEIGHT (VISCOSITY NUMBER AND K VALUE):-

The average molecular weight of a PVC polymer is usually designated by the viscosity number of the `K value` Both are calculated from the results of determination of the viscosityof a dilute solution of the polymer

The concept of K value was first interoduced by H Fikentscher* as an index of the molecular weight of cellulosic it is dependent on the nature of the solvent but little influenced by the concentration and the temperature of determination
For PVC the Fikentscher K value is related to the viscosity ratio n / n_0 by an expression of the type

$$\ln (n/n0) = \frac{cK}{1000} \left[\frac{75K}{1\ 5\,cK + 1000} + 1 \right]$$

The main parameter determination the molecular weight (K value)of PVC polymer in all the main polymerisation process is temperature (in bulk polymerisation the temperature in the second stage) Increasing the temperature reduces the molecular weight of the polymer formed In emulsion and solution polymerisation addition of chain transfer agents can also play a part In some

solution system chain transfer to the solvent may limite the maximum molecular weight obtainable in particular condition

POLYMER PARTICLE CHARACTERISTICS

(a) PARTICLE SIZE AND SIZE DISTRIBUTION

The particle size range characteristic for the main polymerisation processes are indicated in table1 3 togther with the parameters which govern the particle size in each process

(b) PARTICLE SHAPE AND MORPHOLOGY

The grain of a typical suspension polymer have a substantial dagree of sphericity Under sufficient magnification in reflected light they exhibit the characteristic puckered surface Viewed in transmitted light (especially with the grain partly transparentised, e g by plasticiser absorption) a particle is seen to be surrounded by a dence skin enclosing a porous interior made up of cluster of small primary particles of the order of 1um in size, and the associated interstitial voids

Bulk polymer grains are similar in general overall shape and uniformally to those of suspention polymer, although they usually have a characteristic flat sided appearance and a sample will usually contain some fines Their internal structural is also closely similar, but they have no outer skin, so that their internal pores are more directly accessible

STABLIZERS -

PVC is a heat and light sensitive material, since PVC experiences heat in mixing cycles and processing. It has to be stabilized to with stand the heat applied

PVC degrades by dehydrochlorination and subsequent oxidation the function of stabilizer is to delay degradation by absorption of HCl and by absorption of ultra violet energy

PURPOSES AND FUNCTION OF STABILISERS IN PVC

Like the mechanisms of degradation of PVC those of stabiliser action are still not fully understood However it is clear even from quite general consideration that what ever the mechanisms its operation a good stabilisers should prevent or disrupt the reaction Instrumental in thermal degradation of PVC to this end it should in particular rapidly bind and inactive any reaction products which may further impair stability (Especially free HCl generated by dehydrochlorination) deactive potantial initiation sites in the PVC polymer (e g by substituting stable groups for lable Cl atom and reacting to saturate double bond) React with free radicle deactivate oxygen bearing groups and neutralise the destabilising effect of impurities A good light stabiliser should be similarly functional with respect to photodegradation as well as preferably having a screening action against ultra violet radiation of the sunlight spectrum

Different type of stabiliser used for PVC resin are

1. Lead salts
2. Calcium zinc
3. Barium cadmium(Ba/Cd and Ba/Cd/Zn stabiliser)
4. Tin mercaptides (organotin stabiliser)

The proper selection of stabiliser depends on the end use requirments

BARIUM/ CADMIUM AND BARIUM/ CADMIUM/ ZINC STABILISERS

In terms of the amounts used this is the most important group among PVC stabilisers, although none of its member can equal the organotin systems in stabilising power and versatility (in the sence of equal suitability for use with all grades and type of PVC polymer) However system of this type can impart high degree of thermal stability, good light stability, and be compatible with good clarity in transparent compounds Their effects are improved (and especially the light stability increased)by the addition of epoxy co-stabilisers and organic phosphite chelators and these synergists are normally included either by the formulator or ab initio as constituents of the composite properties systems

Weathering properties are further improved by addition of UV absorvers Liquid Ba/Cd and Ba/Cd/Zn systems are particularly widely used in flexible PVC materials typically at levels of 1-2 phr(with about 501 0 phr of a chelator and up to about 5phr of an epoxy co-stabiliser where appropriate)

Solid (power or flake) systems are combinations of the metal soaps, with or without the further additives just mentioned Whilst they can be used in both rigid and flexible compositions they are of special interest for uPVC as they have some lubrient action and affect the softening temperature less than do liquid stabilisers In most cases they are suitable for translucent compositions but only some are suitable for highly transparent ones Typical incorporation levels are 2-3 phr, with a phosphite chelator for improved initial colour transparency and light stability an epoxy co-stabiliser may be included for further improvements in general stability

and light and weathering resistance Combination of solid and liquid systems may be used for optimum flow and lubrication characteristics in particular compositions

The main general limitations of Ba/ Cd and Ba/Cd/Zn systems are differing effectiveness in different types of PVC* (also influenced in a given type of composition by the ratio-and respective contents of the Ba and Cd components the amount of Zn components it present and the nature of the organic parts of the compounds), variable tendency to plate out in processing and susceptibility to sulphur-staining

CALCIUM/ ZINC STABILISERS

Members of this systems are the most widely use non toxic stabilisers for PVC Stearates and octoates of the two matals and many of their properties combinations are widely permitted in most countries for use in rigid and plasticised compositions for the production of food packaging materials and containers medical goods and toys

Ca/Zn combination are not very powerful stabilisers Wherever possible (and this is permitted in many non-toxic applications) they are used in conjuction with an epoxy co-stabiliser(which is a component of many properties systems) to improve the stabilising effect both against heat and light and an organic phosphite synergist Other organic synergists availble for use to improve the stabilising action and efficiency of Ca/Zn systems include stearoylbenzoylmethane and some properties polyol compounds stability improvement by factors up to *2 can be obtained in some composition through the addition of these compounds

The Ca/Zn stabilisers are available in both solid and liquid forms In addition to the conventional powders, the solid versions now include particulate concentrates in PVc polymer Where a liquid system consisting of Ca and Zn soaps in a liquid carrier is to be used for a non-toxic application it is necessary to ascertain that the carrier is acceptable for the purpose

Typical incoporation levels may be illustrated by the following figures, liquid Ca/Zn system for paste composition 1 5 to 3 phr, solid system for sheeting composition 1 to 2 phr , 5-1 5 phr in each case with the addition of an epoxy co-stabiliser Out side the non-toxic field a common use of technical grades of Ca/Zn stabiliser systems is in asbestos-filled PVC flooring, such composition are subject to discoloration during heat processing, due to the catalytic action of iron present in the asbestos In compositions otherwise adequately stabilised with Ba/Cd or lead systems the discoloration can be severe, but it can be effectively prevented by the Ca/Zn stabiliser

Apart from the special applicability of the non-toxic grades, the advantages of Ca/Zn stabilisers include moderate price, and virtual freedom from odour in finished products and from sulphide staining The soap composition have some lubricant action The main limitation are the relatively low stabilising power already mentioned rapid progress of degradation once commenced in Ca/Zn stabilised composition unsuitability for outdoor application and limited suitability for crystal clear compositions

LEAD STABILISERS:-

Neutralisation of nascent hydrogen chloride is thought to be the main mechanism whereby these stabilisers exert their effect This view accords with their basic nature, their mode and rates of reaction with HCl, and the formation of lead chloride during heat treatment and service of lead stablised PVC composition Unlike the chlorides of some other stabiliser metals, this salt does not promote degradation of PVC polymer The known fact that in general the performance of lead stabilisers is not much improved by the presence of co-stabilisers (especially the chelators or metal carboxylate used as components of mixed metal stabiliser systems) is probably associated at least to some extent with the inactivity of lead chloride in this sense since de-activation of stabiliser decomposition products and impurities is believed to be one of the main function of such additives

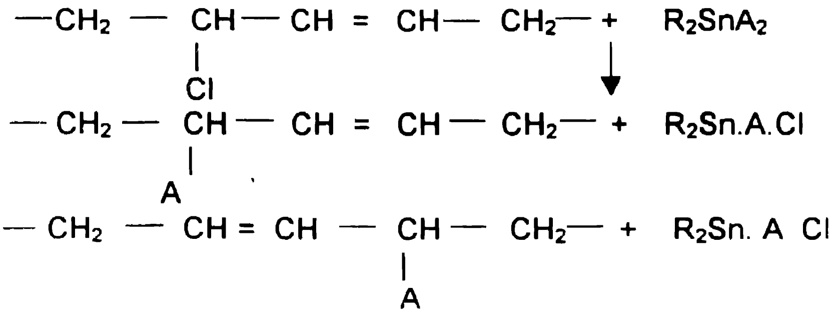
ORGANOTIN STABILISERS:-

These stabilisers are belived to function in several ways Dialkyltin chlorides have been identified among the volatile evolved in the heat processing of PVC compositions stabilised with dialkyltin compounds A corresponding drop in the Tin content of the composition has also been observed, increasing with time of treatment These observation are consistent with the binding of hydrogen chloride by the stabiliser, presumably in accordance with the general reaction

$$R_2SnA_2 + 2HCl \longrightarrow R_2SnCl_2 + 2HA$$

Where A is a mercapto or carboxylic acid substituent, like lead chloride, the dialkyltin chlorides do not impair the stability of PVC polymer

Work with model compounds (employed as PVC polymer analogues) has shown that organotin stabilisers can replace labile chlorine atoms with their own ligand (A) groups, whereby the stability of the thus substitute compound is significantly increased The substitution could be either direct or possibly on the carbon originally in the 4 position to the chlorine,



$$-CH_2-\underset{Cl}{\underset{|}{CH}}-CH=CH-CH_2- + R_2SnA_2$$

$$\downarrow$$

$$-CH_2-\underset{A}{\underset{|}{CH}}-CH=CH-CH_2- + R_2Sn.A.Cl$$

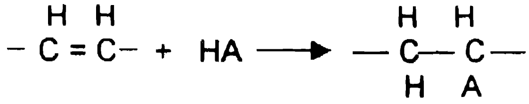
$$-CH_2-CH=CH-\underset{A}{\underset{|}{CH}}-CH_2- + R_2Sn.\ A\ Cl$$

It has also been suggested that organotin stabilisers may be able to form transitional complexes with instability centers in the polymer. It would appear that free radical scavenging proposed in the case of some mercaptides, may be among the modes of action of organotin stabilisers.

Colour development in PVC composition as a result of heat processing may be reduced in some cases substantially by post treatment with an organotin stabiliser. This indicates that yet another way in which these stabilisers perform their function is to react with chromophoric groups. The chemical transformation suggested to account for the raduction of colour included reaction of the stabiliser with any carbonium groups formed in the course of PVC degradation, and with double bonds in conjugated system.

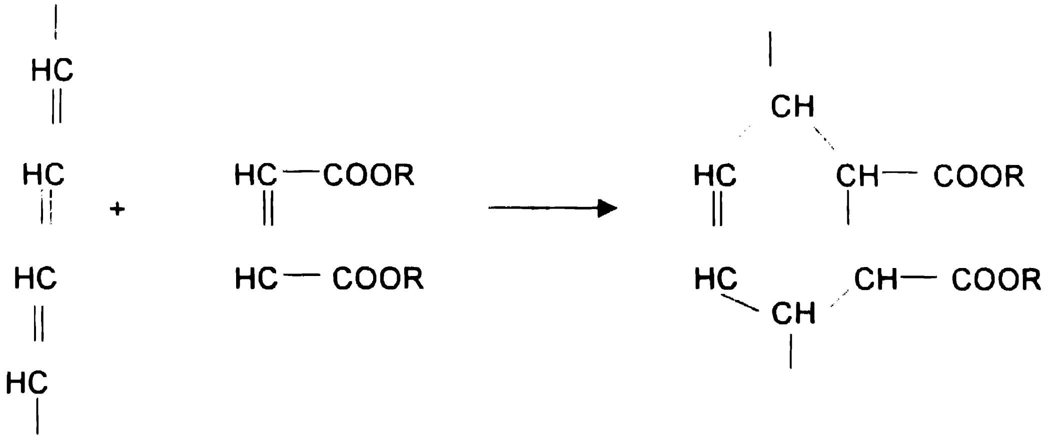
The latter type of action would interrupt the conjugated double bond sequences (thus reducing colour due to their presence) and also increase the

general stability of the polymer chain; two mechanisms proposed for this are noteworthy. According to one the carboxyl or mercapto compound generated by the organotin stabiliser in its reaction with HCl may react with a double bond in the polymer chain;



$$-\overset{H}{C}=\overset{H}{C}- + HA \longrightarrow -\underset{H}{\overset{H}{C}}-\underset{A}{\overset{H}{C}}-$$

Some support for the idea of this kind of effect is provided by an experiment in which the colour of a heat affected PVC material was considerably reduced by re-processing with 1% of the isooctyl ester of thioglycollic acid (even though this entailed a further heat treatment at 180^0C). The other possibility suggested is that where the regenerated compound (HA) is a maleic acid derivative, it may enter into a Diels Alder reaction with a diene section of the polymer chain thereby eliminating a double bond and introducing into the chain a relatively stable ring structure;



The fact that dibutyltin maleate is a better heat stabiliser than the corresponding succinate has been cited in support of this possibility.

PLASTICISERS:-

A plasticiser or softner is a subatance or material incorporated in a material to increase its flexibility, workability or distensibility. A plasticiser may reduce the melt viscosity, lower the temperature of the second order transition or lower the elastic moduls of the melt.

This may appear to be an unnecessary elaborate definition, but it highlight the many function a plasticiser can have in any given polymer plasticiser system. Thus for surface coating and thin films a plasticiser may be defined more specially as a compound which gives flexibility impact resistance handle feel etc In rubber plasticiser reduce stiffness permit easier processing and may improve flexibility at lower temperature . In thermosetting polymer and certain rigid thermoplastics they assist processing and ease of moulding. In PVC plasticiser convert the rigid intractable resin into workable compound which can exhibit a wide range of properties, depending on the type and concetration of plasticiser used

The properties required of plasticisers, or the plasticied PVC products generally include compatibility with the resin non-volatility, non-flammability, good heat and light stability, good low temperature performance and non-toxicity To some extent these requirments may conflict, and no single plasticiser can satisfy them all completely. For this reason plasticiser mixture are used. In practice the choice of plasticiser or even plasticiser mixture will usually involve some form of compromise.

Plasticiser may be divided into two groups primary and secondary with the rather arbitrary division between them depending mainly on their compatibility with PVC polymers up to at least 150 phr Secondary plasticiser are less compatible and are generally used in mixture with a primary plasticiser in order to confer some special balance of properties The extenders from a branch of this group they have a very limited compatibility but may be include in plasticised composition as a part-replacement for their plasticiser to reduce cost

Plasticisers are the most important used for flexible applications the selection of Plasticisers and their level used depends on various factors such as

1 Hardness

2 Flexural elastic and tensile modulus

3 Performance

4 Electrical properties

5 Service temp

6 Barrier properties of films

7 Burning behaviour

8 Toxicity

The most widely used Plasticisers are

1. Phthalates Plasticisers:-

They are generally used for good compatibility for good softness for good colous etc

e g DOP, DIOP, BBP DBP, etc

2. Phosphate Plasticisers:-

They are generally used for good tensile strength for high electrical resistance and for non flammability

e.g. TCP, TOP, etc.

3. Sebacates, Adipates Plasticisers:-

They are generally low temperature Plasticisers and used for low resistivity

E.g. DBS, DAS, DOS, DOA, DIOA, DDA etc.

4. Polymerie Plasticisers:-

They are used for low volatility and for high viscosity pastes

e.g. PPA, PPS, etc.

5. Secondary Plasticisers:-

They are used for cheapness for non flammability, Epoxidised oils are used for stabilising effects against heat light and weathering

e.g. CPO,CPW, Epoxidised oils and esters etc.

FILLERS:-

Fillers may be defined as solid particulate or fibrous materials substantically inert chemically incorporated in plastic compositions (including PVC) to modify the properties or to raduce material cost.

The function of fillers is to reduce the cost of compound at low levels and also to improve the impact properties, to some extant it also gives a drier feel and

reduce the glass of the final product. Most commonly used fillers for PVC are $CaCO_3$ talc and clay.

TALC:- This material also consists of hydrated magnesium and SiO2. The chemical composition and the particle shape of talc vary some what according to the source. The shape may also be influenced by the grinding process the particle may be granular plate like or needle shaped with sizes in the range 1- 50 um3. Talc is used in some calendered PVC floor tile compounds to increase melt cohesion and the stiffness and hardness of the finished product its low tinctorial power.

CLAY:- there are several varieties of clay all essentially forms of complex hydrates alumino silicates with varying amounts of other minor constituents (including oxides of Zn K and Ti) of the various clays only kaolinite is significant as a filler for PVC used the main uses of china clay in PVC are as a filler in some Plasticised compositions for extrusion and calendering and pastes. It is also used in some formulation for PVC hose, wellington, boots, floor tiles, and rigid PVC pipes and fittings.

LUBRICANTS:-

Lubricants are essentially processing additives: their primary role is to influence some aspects of behaviour of PVC composition under the heat and shear experienced in the processing machinery. The component of PVC formulation can have lubricants effects and influence the performance of or requirment for the lubricant proper.

The principal external Lubricants effect is the reduction of friction and sticking between the hot PVC composition and the working surfaces of processing

machinery due to the presence of a layer of Lubricants at the interface and metallic surface. This lubrication are known as external Lubricants they are normally nonpolar hydrocarbon such as paraffin , wax, and mineral oils.

The basic internal Lubrication effect is the lowering of internal (i.e. inter molecular) friction in the polymer. Which brings down the melt viscosity. They are normally polar molecules either fatty acid or their esters or metal soaps.

The chemical structure of the Lubricants is both the prime factor in its compatibility with PVC and the link between compatibility and the mode of Lubricant action. Results of experimental studies in this area and in particular those of the authoritative work of Illmann are consistent with the theoritical expectation that the molecular size and polarity of a Lubricant are the main factors determining the compatibility and lubricant behaviour; broadly speaking short chain length and high polarity make for good compatibility and internal Lubrication whereas relatively long-chain compounds tend to be poorly compatible and act as external Lubricants.

The type of chemical compound used as Lubricants in PVC are shown in table among those typical examples of low compatibility and external Lubrication effect are provided by say the polyethylene waxes and calcium stearate. Whilst relatively high compatibility and assotiated internal Lubricants action are exemplified by the partial esters of glycerol.

Whereas rigid PVC composition normally require both internal and external lubricants only external lubricants will usually be considerd for flexible composition as in those the plasticiser will provide internal lubrication. However an external

lubricant may be useful or necessary even in such heavily plasticised composition as certain plastisols especially for intricate mouldings

TABLE:

Compounds Used as Lubricants Table 11

General type	class of compound	Examples
Hydrocarbons	Natural hydrocarbons	Paraffins paraffin oils
	Synthetic hydrocarbon	Synthetic paraffins,low molecular weight polyethylene
Hydrocarbon Derivatives	Fatty acids	Stearic acid
	Fatty alcohols	Cetyl, Stearyl Octadecyl
Derivatives Of organic acids	Metal salts	Stearates of barium calcium aluminium and lead
	Amides	Stearamids
	Esters and partial esters	Butyl stearate, glycerol monostearate,glycerol monoricinoleate
	Wax esters	Stearyl esters, montan acid esters

PROCESSING AIDS

The processing aid plays its role in reducing melt viscosity The most common processing aids used are acrylic polymer Rigid PVC melts are prone to rupture under high stress and may of the practical processing problem encountered to remove them processing aids are used

The polymer used as processing aids in PVC are of the following kinds,

(a) Acrylates and methacrylates (acrylic processing aids),

(b) Styrene/methacrylate copolymers,

(c) Acrylonitrile/butadiene/styrene (ABS) polymers,

(d) Styrene/acrylonitrile (SAN) copolymer

(e) Poly-a-methylstyrene (PAMS)

The molecular weight of the PAMS grades marketed as processing aids for PVC is low compared with those of other processing aids Some ABS polymer are used also as impact modifiers One of their composition related properties the modulus of elasticity, is sometimes cited as a rough index of the type of their effect in PVC compounds, those useful as processing aids have the highest moduli, whilst the moduli of ABS impact modifiers are comparatively low

Processing aids are employed in rigid PVC composition, in relatively low proportions to facilitate melt processing

(i) Increased rate of homogenisation and fusion except in the case of lubricating processing aids which extend fusion time

(ii) Improved strength cohesion and extensibility of the melt

(iii) Reduction of melt modulus and nerve die-swell and tendency to melt fracture,

(iv) Incresed melt viscosity (except with PAMS by which it is reduce in most types of uPVC composition

(v) Tendencyto increase torque and back -pressure in extrusion attributed to the faster higher shear character of the fusion process

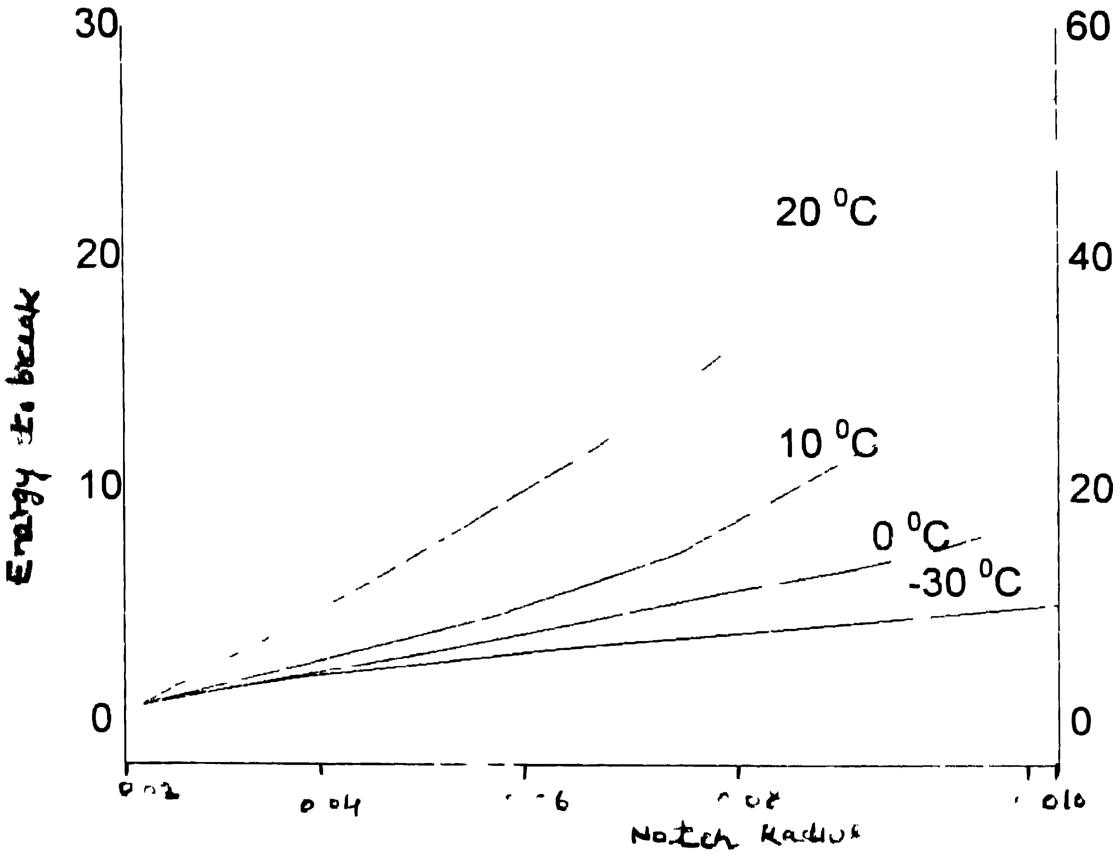
IMPACT MODIFIERS

As the name indicates impact modifiers are used to enhance impact properties of PVC there are all polymeric additives, which act as shock absorbers in the structure of PVC the most common impact modifiers are Methylmeth acrylate, Butadiene, Ztyrene,(MBS) Acrylenitrile Butadiene, Styrene(ABS) chlorinated polythylene(CPE) etc. MBS modifiers are generally used for manufacture of transparent blow moulded bottels since a careful matching of refractive index with that of PVC allows production of glass clear bottles.

THE IMPACT RESISTANCE OF PVC

With PVC products the possibility of fracture by impact in service is of greater concern in the case of unplasticied composition than with pPVC Whilst some plasticisers can make the plasticied material prone to embrittlement at temperatures within a moderate range for service, this can easily be avoided by suitable formulation Thus in general flexible PVC composition are tough materials Which do not normally fail by fracture on impact in service or in tests

Impact resistance of a uPVC composition as a function of notch tip radius in a charpy type test at various temperature.



MISCELLANEOUS ADDITIVES

ANTISTATIC AGENTS

PVC products and articles may readily accumulate static electricity charge under certain condition There results in attraction of dust or a shock to the operator through sudden discharge or an explosion hazard if a spark is generated in flammable atmosphere thus to prevent static electricity charge build up antistatic agents are used

Antistatic agents are chemicals which normally bring about a drop in the volume and surface resistivity of plastic materials There are esters of fatty acids ,Amine acids, Quarternary ammonium compounds etc

Like many other plastic materials PVC products and articles may readily accumulate static electricity charges under certain condition Friction against, and separation after surface contact with other surfaces are common ways of charge generation Since surface charges leak away more easily in moist condition the highest and most persistent charge result at lowest relative humidities above approximately 80%

Accumulated static charge can represent a serious potential hazard For example when present on the cover or carcass of a PVC conveyor belt the charge may on discharge produce a spark which can cause a fire or an explosion in a dust laden atmosphere such circumstances can arise in mines, where PVC sheeting can constitute similar hazard in other environments Charge built up on PVC polymer particles can be troublesome as can those acquire by dry blend particle in the course of high speed mixing can affect the bulk density and handling properties although they often eventually ,finally attraction of dust and other atmospheric pollutants to charged plastics surfaces can result in dirty marks

For all these reasons it is necessary to have method of preventing static electric charge build up In general the method employed may be divided in to two broad groups chemical treatment and physical treatment The former treatment involve the incorporation in the PVC material, or external application there to of a chemical (an anti stetic agent) which will prevent the build up of charge The letter are essentially means of ionising the atmosphere (either with the aid of a radio active source or electrical discharge) to enable any charge build up to be

neutralised These physical method are mainly applicable in the handing and processing of sheet materials

FLAME RETARDENTS

The high chlorine content of PVC makes the polymer self extinguishing rigid PVC is very resistant to flame ignition and will not support combustion but flammability of PVC is promoted by plasticisation To impart flame retardency antimony trioxide in combination with flame resistant plasticisers should be used organo antimony compounds such as triphenyl stilbene may be used for imparting flame resistance to transparent PVC compounds

BLOWING AGENT

Blowing agents are compounds which decompose on heating with in a defined temp range to generate a large volume of gas The range and the rate of gas release must be suited to the processing conditions of the PVC composition concerned The blowing agent can be solid or liquid and inorganic or organic in nature

The blowing agent most widely used with PVc is azodicarbonamide other are 4 4 oxybisbenzenesulphonyl hydrazide, azodisobutyl ronitrile etc be capable of producing the required colour and shade

COLOURENTS

They are used to produce deferent colours in the PVC product The colourents used in PVC may be divided in to pigment and dyes

PIGMENT:-

These are fine particle material but soluble in PVC composition The pigments fall in to three main groups inorganic compounds (mainly metal oxides) lakes (dyestoffs precipitated) on to inorganic compounds which act as bases or carrier in this combination and organic compounds

DYES:-

Dyes are colourants soluble in PVC composition They are thus non – opacifying and hence suitable for transparent compounds but in general rather prone to migration from the standpoint of their chemical nature dyes are organic compounds It is self evidence that the colourantss chosen for a particular formulation be capable of producing the required colour and shade

RESISTANCE TO BIOLOGICAL ATTACK

In the plastic context this normally means attack by fungi or bacteria Whilst infection by algae might also be included in the term in its widest connotation it is not a major problem even with such PVC material as film linings for canals, reservoirs and swimming pools

The essential mechanism of microbiological attack is enzymatic degradation of the substrate on which the micro organism grow Both bacteria and fungi produce enzymes capableof breaking down many carbon compounds (those containing oxygen-bearing functional groups can be particular susceptible) to simpler substance utilisable as nuterients

Some of the product of the breakdown process can be coloured, sothat the apperance of colour (in PVC often a characteristic pink stain) or black spots as

well as deterioration of some properties in consequence of the chemical degradation are the main outward manifestation of microbiological attack. other included the development of offensive odours, surface tackiness or surface cracking

In board terms the relevent characteristics and effect of the main components of a PVC formulation may be summarised as follows Like many other synthetic polymers the polymer and copolymer of vinyl chloride are resistance to attack by micro-organism

However some commertial PVC resin may contain residual amount of emulsifying or suspending agents used in their production, and these may be susceptible Many plasticisers are vulnerable to microbiological attack as are some stablisers and lubricants

THE PROCESS DESCRIPTION

The basic process consists of following steps,

1) Physical mixing of raw material additives
2) Compounding
3) Mixing
4) Calendring
5) Printing
6) Lamination

PHYSICAL MIXING OF RAW MATERIAL AND ADDITIVES

In a powder blending operation the PVC polymer powder is mixed with the other formulation components such as stabilisers, Lubricant Fillers ,Plasticisers etc so that the resulting blends is still in particulate form

COMPOUNDING OPERATION AND EQUIPMENT

The compounding process represents the link between raw material production and finished article manufacturer its function is to combine the PVc resin with the varrious additives required for processing and for the service properties of the final product, in accordance with the formulation

PVC COMPOUNDING AND OPERATION

-Preparation of pre mixes and dry blends melt compounding and pelletising

-Compounding for the feeding of film and sheet calendres

-Production of pastes (plasticisers, organosols, plastiqels)

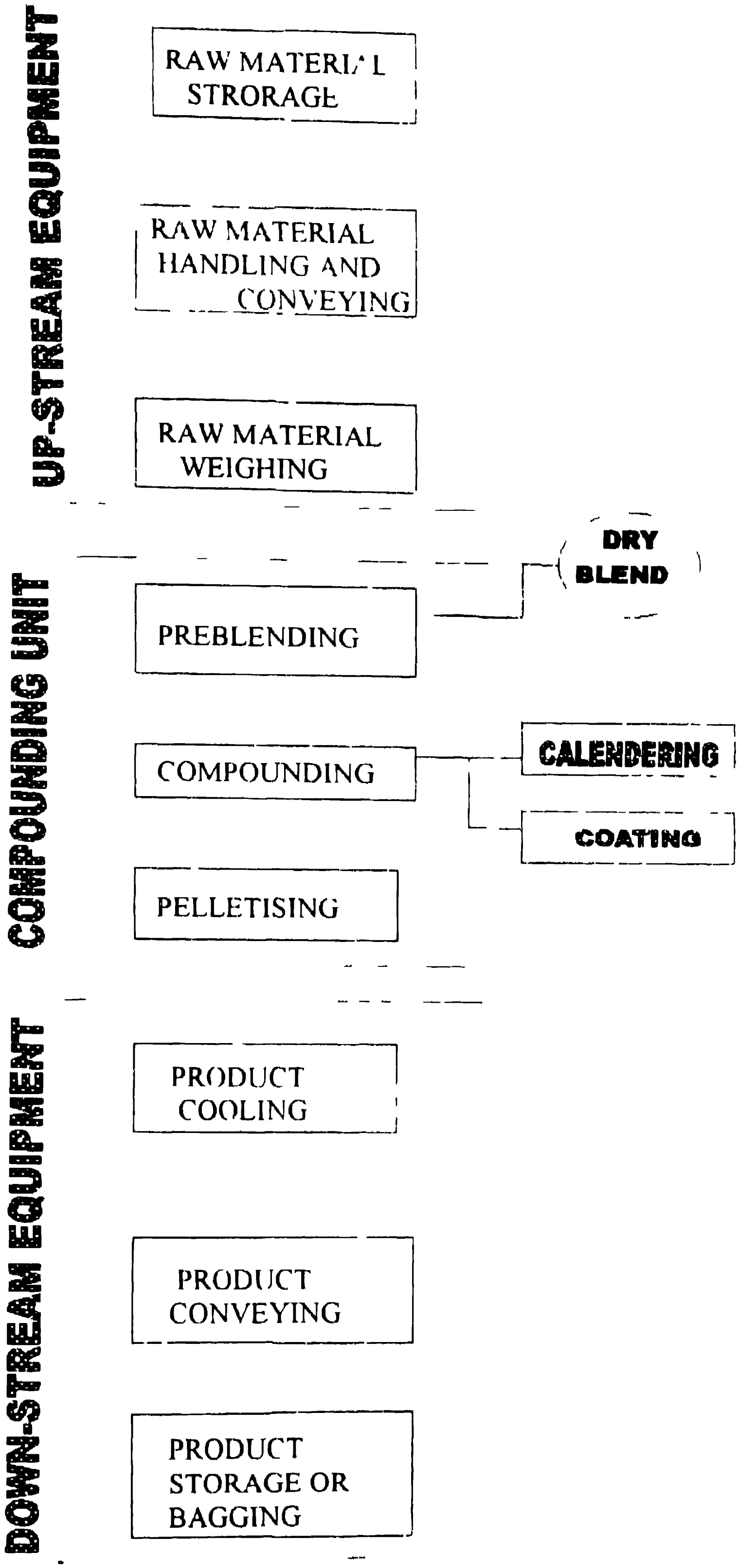
-Recycling

As indicated schematically in fig (A) the equipment required can be divided in to the upstream section a head of the compounder, the compounder itself and the downstream equipment the upstream units are more or less identical for all the five general types of compounding operation but the compounder and its downstream equipment have to be adapted to the specific requirment of each type or typical line is shown in fig

The upstream equipment handles the raw materials It comprises SILO stroage, conveying, weighling included in the compounding section are the PVC

pre-mixing operation the actual compounding and where pellets are produced the pelletising operation Table indicates for some important PVC products the proportion produced respectively from pre-mix and from pellets as the feed stock to interpret the table properly one sould bear in mind that the production of film sheet and of products from Plastisols involves processes withan inline compounding step between premix and final product thus in these cares final product processing follows directly on the compounding operation and there is no need either for pelletising or for the downstream equipment that normally follows that operation

The downstream equipment normally employed for pellets and dry blends handles the cooling conveying storage and packaging of the compounds



FigA P V C compounding block diagram

MIXING

BLENDING OF BULK MATERIALS ON OVERALL SOLID PHASE

The processing of PVC composition for the manufacture of products (e g moulding) or semi-product (e g sheeting) always involves powder blending as an early peocess step During this operation PVC polymer powder is blended with the additives (fillers, lubricants, stablisers, pigments, plasticisers etc) called for by the particular formulation plasticated to a greater or lesser extent and gelled and possibly agglomerated or pelletised Depending on the way the operation is carried out the resulting blend of particulate formulation components can take one of the following three forms which are then processed further as indicated

(i) A free flowing powder blend subsequently used directly for processing into products or semi-products

(ii) A free flowing agglomerate suitable for subsequent direct processing in to products or semi-products

(iii) A powder blend that is only relatively free flowing blends of this type may subsequently be either malt-compounded and pelletised, with the pellets then being used in the production of products or semi-products or melt-compounded for subseequent direct conversion of the compound by calendering into sheet or film

CONTINIOUS DRY BLENDING OF PVC COMPOSITION

Conventional dry blending in the hot or hot/cold mixer is a batch process One step continious dry blending of u PVC and PPVC composition has now also been interoduced Equipment developments include an adaptation for powder blending of the buss MT turbine

THEORETICAL ASPECT OF MIXING WITH SPECIAL REFRENCE TO DRY BLENDING OF PVC COMPOSITIONS

In the simplest case mixing implies the presence of at least two substances with different characteristic These may be totally different substances or variants of the same substance differing merely in physical properties temperature or the like In more complex cases a number of constituent substance may be required for the desired final mixture

The job of the mixer is to combine the substances in such a way that extremely small samples of the mixture (of a size appopriate to the particular application) do in fact contain the constituent in proportion as close as possible to those aimed at Wherever mixing is done on a commercial basis i e by machine the actual proportion will always differ to some extent from the theoretical ideas

The optimum mixture achievable in mechanical mixing is referred to as the ideal random mixture, this can be calculated for specific materials and mixing ratios sample can be taken from an actual machanically mixed composition to determine whether the ideal random mixture has been approximated in the desired degree The methods of statistical probability are an important element of this sample taking and checking, and are integrated into the calculation employed

MIXERS FOR PLASTIC PROCESSING

Virtually every type mixer system on the market finds some application in plastic processing This section deals with mixers for bulk materials in the solid overall phase, applicable to PVC composition Mixer systems for promarily liquid phase used in the production of plastisols are discussed in a later section A mixing operation is integrated in to every kneading process for compounds in the highly viscous plastic, or paste like overall phase handled with internal mixers screw type kneaders or extruders This aspect too, is dealt with in a later section

MECHANICAL MIXERS

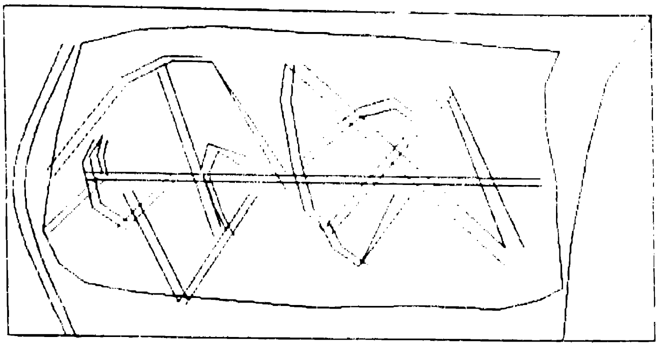
MIXER WITH ROTATING CONTAINERS:-

Operating principle in rotating container the free flowing bulk material is carried along by the tank wall by means of friction, and raised up until it flows back down the incline formed The cascade motion produced at low speeds becomes a cataract motion at higher speeds where by the particals are intermixed more intensively and the mixing time is considetably reduced All mixers of this type produce a continious interleaving and re-forming of the material which is thus repeatedly divided and reunited in a different arrangement The mixing process takes place virtually without shearing forces and affords gentle product handling

RIBBON BLENDER MIXER

Ribbon blenders have a slow turning agitator that works in conjuction with counter-flow screws or counter-flow baffles to mix the product axially and tangentially Because hardly any kinetic energy is converted to heat these mixer

require relatively low driving power on the other hand. the energy is insufficient to produces the fineness of dispersion called for in many cases.



Ribbon blender

Sifting and grinding operations are therefore used following, or between mixing processes of this type these moxers make it possible to prepare large quantities of uniform stock or finished pastes, but they suffer from the drawback of being hard to clean. Axially removable agitators have improved matters lately however ribbon blenders are used preferably for very long runs with infrequent colour changes.

TEMPERATURE CONTROL MIXING

The shearing forces generated by the rotors and the mixing chamber walls permit adiabatic operation of the FCM. To avoid product overheating, the rotor shafts are hollow and the mixing chamber is provided with a jacket 3t, so that water cooling can be carried out since the outlet flap is plated for PVC products there is no need to controle its temp. de-gassing vaccuum can be applied to the connecting tube between the FCM and pelletising extruder.

chamber barrel away hydraulically and swinging it 60 away from the kneader axis This makes the rotors and barrel bores freely accessible for cleaning

TABLE:- 1 2

Technical data for the FCM

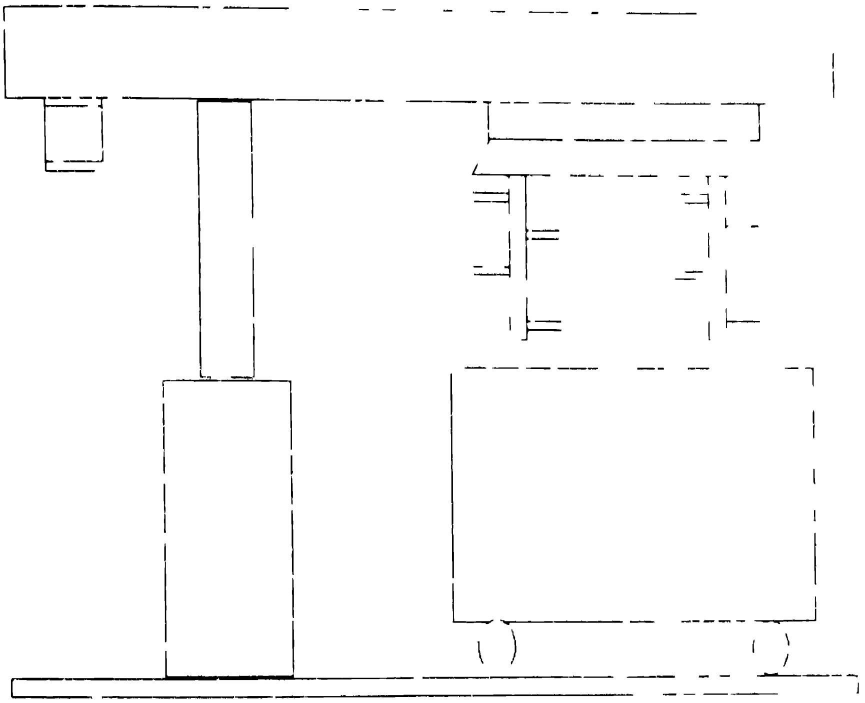
	Modles			
	2FCM	4FCM	6FCM	9FCM
Volume (dm3)	344	2 70	9 13	30 8
Max torque(Nm)	187	1432	7162	28640
Standard gear box				
Max rating (kw)	22	73 5	257	882
Max screw speed (r min-3)	1150	100	350	[illegible]00
Special gear box				
Max rating (kw)	--	-	--	1102
Max screw speed (r min-3)				375
Dimensions with drive				
Length (m)	2 0	4 2	6 0	7 0
Width (m)	1 5	1 1	1 5	2 0
Height (m)	2 8	1 6	1 3	1 6
Weight without drive (kg)	2050	2730	6700	9600
Production rate				
Plasticised PVC (kg h ^{1})	165	650	2000	5000
Rigid PVC (kg h ^{1})	90	3000	1100	3750

ROLL MILLS:-

Three roll mills with two shering nips are normally used for producing PVC pastes on this type of equipment Nip pressure roll speed and roll speed differentials (which produce the shear) must be set appropriately for PVC pastes

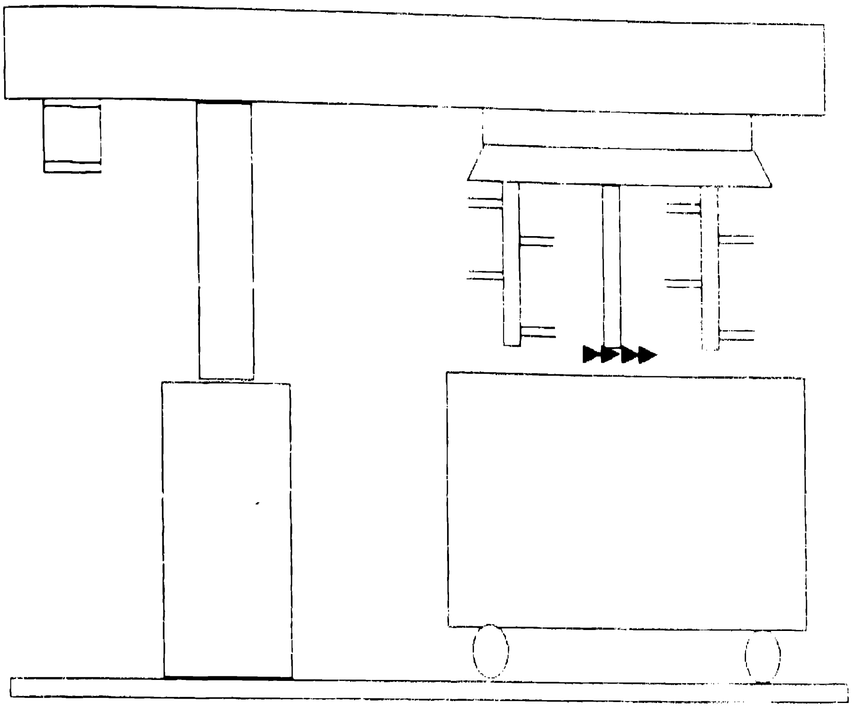
MACHINES FOR THE PRODUCTION OF PASTE FOR PIGMENT:-

In these mills the friction gaps required to achieve dispersion are provided by balls moving past one another Where ball diameter are relatively large it is sufficient to tumble them in drums



Planetary mixer (a) Basic

To meet more exacting dispersion requirments however small spheres or beads of glass ceranmic materials or steel or silica sand are used kept in motion by agitators Because energy input is relatively high ball mills are used mainly for producing colour pastes

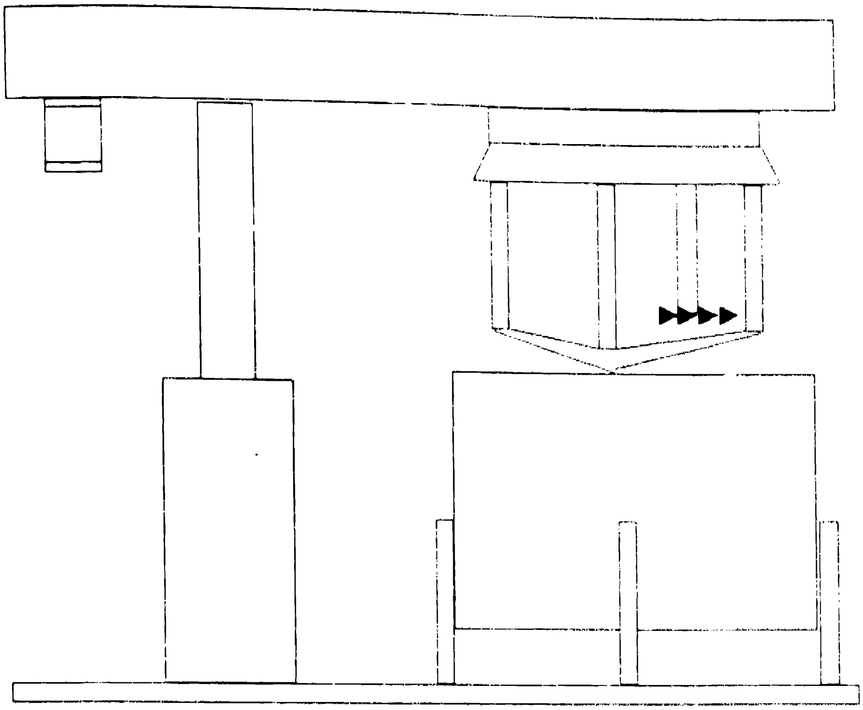


(b) with internal pin mill

Horseshoe Mixer

In a recent development cooled agitating disks and cooled housing are being tried to eliminate excessive heating.

Ball wear and screening of the balls deserve special attention. Because of cleaning expences these mills are used only for long production runs



Horseshoe mixer

CALENDERING:-

The calendering process in its simplest form is employed to produce continuous films and sheets. The main part of a calendering machine is a set of highly polished metal rollers rotating in opposite direction with provision for precise adjustment of the gap between them. The gap between the rollers determine the thickness of the sheet calendered out. Compounded polymeric material is fed between the rollers which are maintained at an elevated temperature. and the sheet emerging from the rollers is cooled by passing through cold rollers. The sheets are finally wound up in rolls by incorporating a suitable engraved embossing

rollers in the calendring machine emboned sheet of suitable design could be prodeced The arrangement of rolls in calender can be five type

1 L type

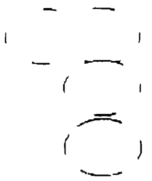
2 Inverted L type

3 Z type

4 Inclined Z type

5 Two roll calandre

In our company we are using Inverted L type calender



L type

Z type

SPECIAL LINES & ARRANGEMENT:-

(a) Calendred Flooring Lines:-

Heavily filled vinyl/asbestos flooring composition are difficult to process on a conventional calender because of their stiffness hardness and relatively low resin content more over the thickness in which the material is required may range up to 5mm for these reasons material of this kind is calendered on a sequence of two or three individual two roll calendering units withvertical or inclined roll arrangement

The compounding and feed section of a typical line may be similar to that shown in fig H But with two mills between the internal mixer and the first

calendering units in the production of the familiar matteled PVC flooring or tiles. multi coloured vinyl chips are added either on the first mill or second mill which feed the first calendering unit the function of this and the subsequent units is ensentially to roll out the sheet as it makes its straight passage through the nip so that the sheet thickness progessively reduced the operation is thus some what askin to the rolling out of ingots in sheet metal production. The sheet emerging from the nip of the final unit is cooled and wound of cut up as required.

Fully flexible flooring composition whore relative resin content is substantially higher can be processed in the normal way three roll calender are quite often used or four roll calender operated with a spining bank or a spewing bank of stock before the second nip.

Sheets of suitable flooring compositions calendered in the normal way on a three or four roll calended can be laminated by various thechniques to produce multi-layer flooring of the type conventionally. If some what in congruously styled homoqeneous. The individualplies piles may be of the some or defferent composition.

LAMINATION ON OR AT THE CALEDER:-

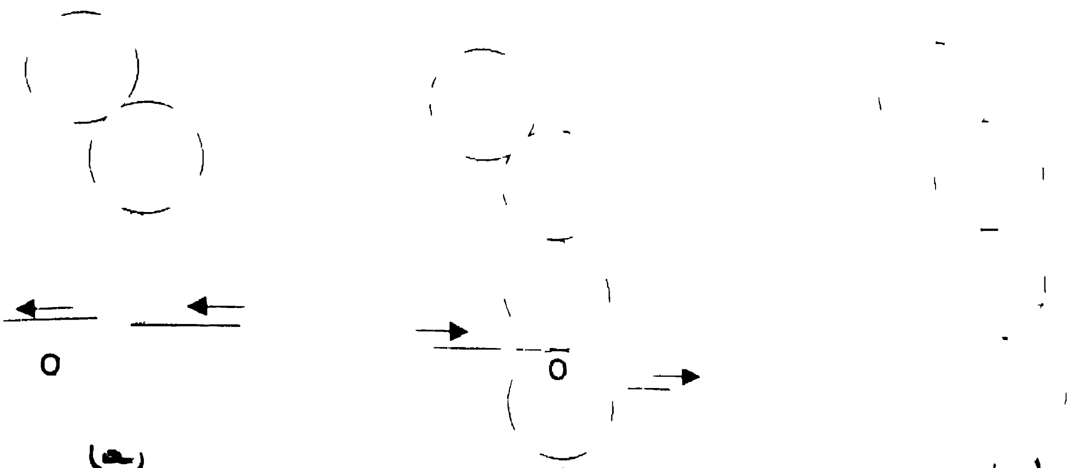
The function of a laminator is to laminate two or more layers together to from a single layer applying heat presure and / or adhesive.

Calendered PVC films can be laminated on the calender or in line to other continious web material such as textile fabrics felt paper and films. In principal the range of PVC coated fabric and paper which can be produced by lamination with flexible calendered film is equivalent to that of similar material made by the paste

coating In partice the coating route offers greater formulation versatility and operational flexibility especially for relatively short runs for multi layer coatings and where frequent formulation charges are made calender lamination can be economically attractive where long continuous runs without formulation changes are involved product properties are broadly comparable but the change and quality of cellular coating layers are better in paste produced coating whilstsolid coating of this kind are completely free from orientation and strain which may not invariable be the case with some laminated film coatings

There are three basic ways in which a freshly calendered PVC film can be laminated to a continuous web ofanother material additional equipment is also normally necessary for unwinding the web to be nip as well especially with fibrous webs arrangement for drying and pre heating the web

The in line lamination method shown in fig © is of special interest with heat sensitive substrates or where an adhesive layer is to be applied prior to lamination In the calender nip lamination arrangement illustrated in fig ب the degree of penetration of the hot film in to a porous substrate say a fabric being coated by the method increase with decreasing gap between the nip forming rolls and with increasing friction ratio between them zero friction and a suitably wide gap should be employed for minimum penetration similar considration apply to fabric lamination on the calender roll with a squeezz roller as shown in fig b



(a) (b) (c)

Lamination or web coating with PVC films on a inverted L calender schematic representation (a) nip lamination (b) lamination with a squeezz roller against calender bowl (c) in line lamination

PRINTING:-

As the name indicates the function of printing M/C is to the print certain design in different colours on the surface of the film care has to be taper While preparing the printing ink for this the viscosity of the ink should be maintained nearly constant through out the process As the ink is prepared by adding solvent so volatile loss can take place in our company we are using R gravure printing machine

METHOD OF TEST FOR PLASTIC FLOORING FROM I. S. STANDARD:-

(SECOND REVISION)

This Indian standard was adopted by the Indian standard Institution on 31 January 1986, after the draft finalized by the flooring and Plastering Sectional Committee had been apporoved by the Civil Engineering Division Council

INDIAN STANDARD SPECIFICATION FOR UNBACK FLEXIBLE PVC FLOORING:-

Flexible PVC flooring have been in use in the country for more than a decade, It provides dust free noise absorbing resilient and decorative surface for building of various types The floor covering is available in different shades and design

There are two kinds of PVC floorings One is flexible which is available in sheet form and the other is rigid which is available in standard tile sizes Flexible PVC flooring is suitable for comparatively lighter traffic either for rigid floors such as concrete and stone flooring or for flexible floors such as timber flooring etc Asbstos PVC flooring tiles are rigid comparatively more suitable for heavy traffic and for rigid floors Flexible PVC flooring are not suitable for areas and surfaces exposed to sun and light

PVC flexible flooring is liable to be charred by cigarette burns leaving a permanent mark

This standard was first published in 1966 and subsequently revised in 1979 The important changes made in this revision are

(a) The clause for conditioning the sample has been included and the conditioning of test specimens in water has been excluded

(b) Thickness of wearing layer of laminate type flooring has been excluded

(c) The requirement for tile size variation has been increased to 13 from 10 percent with a maximum variation limited to 40

(d) Requirement of colour fastness to datlight has been changed to standard No 4 when tested in accordance with IS 9766-1981

TABLE 1 3

REQUIREMENTS OF FLEXIBLE PVC FLOORING

SL	CHARACTERISTIC	REQUIRMENT	METHOD OF TEST
(1)	(2)	(3)	
i)	Thickness	The mean thickness shall not differ by more than 13 mm from that specified The variation between any Two measurement shall not Exceed 20 mm	
ii)	Width of sheet or roll	Width shall be not less than that specified dimensions and not more than 6 mm greater than that specified	
iii)	Tile size	The dimension shall not vary from the specified dimension by more than 13 percent or +- 4 mm whichever is less	
iv)	Squareness	Gap between the sides of the tiles and the arms of the metal jig shall not be greater than 15 mm towards the farther end from the junction of the arms	
v)	Dimensional stability	Change in any linear dimension shall not exceed 4 percent for sheet and 25 percent for tiles After the test the speciman shall Show no signs of curling	
vi)	Colour fastness to daylight	Shall be rated not less than standard 4 when tested in accordance with the 4 3 of IS	

vii)	Curling	Shall not exceed 75 mm
viii)	Residual indentation	Shall not exceed 10 mm
ix)	Flexibility	Shall not break crack or show any other signs of failure
x)	Resistance to various substance	The average scratch width obtained after immersion shall not exceed 2 0 mm The colour of the treated pieces shall show no significant change when compared with untreated material
xi)	Ply adhesion	Adhesion between plies in any test piece shall not be less than 1 05kN/m
xii)	Moisture movement	Change in any linear dimensions shall not exceed 4 percent
xiii)	Heat ageing and exudation	No exudation of plasticisers shall be apparent nor shall there be any change in appearance The mandrel test shall not produce surface cracking
xiv)	Elastic product	The mean product of tensile strength and elongation shall be not less than 2 MJ/m^2

COLOUR AND SURFACE CHARACTERISTIC:-

The flooring shall have a uniform wearing surface The colour and also pattern, marbling or mottling if present shall extend through the full thickness of the flooring, when the flooring is not laminated In case of laminated flooring it shall extended to the full thickness of the top layer The colour and the pettern shall match the sample that is agreed upon by the purchaser and the supplier

TESTS:-

The tests shall be of three categories as given below

TYPE TESTS:-

Tests carried out to prove conformity to the requirment of this standard

These tests are intended to check the general qualities and design of the flooring

ACCEPTENCE TESTS:-

Tests carried out on sample of flooring selected from a lot for purpose of accepetance of the lot

ROUTINE TESTS:-

Tests carried out on each and every tile/roll/sheet to check the requirment which are likely to vary during production

CATEGORIES OF TESTS:-

Type tests - The following shall comprise the type tests

(a) Colour and finish

(b) Dimension and tolerances

(c) Squareness

(d) Dimensional stability

(e) Colour fastness to daylight

(f) Moisture movement

(g) Curling

(h) Heat ageing and exudation

(i) Residual indentation

(j) Flexibility

(k) Resistence to various substances

(l) Ply adhesion, and

(m) Elastic product

ACCEPTANCE TESTS :-

The following shall comprise the acceptance tests Acceptance tests shall be made on samples selected from each lot in accordance with the sampling procedure detailed in appendix

a) Dimension and tolerances

b) Squareness

c) Dimensional stability

ROUTINE TESTS:-

The tests on colour and finish shall comprise the routine tests to be carried out on each and every tile or roll or sheet

METHOD OF TEST FOR FLEXIBILITY

OBJECT:-

To determine the flexibility of PVC flexible flooring

APPARATUS:-

A 40 mm diameter mandrel and a low temperature equipment capable of maintaining a temperature of 0+ 0 5 °C

PROCEDURE:-

The tests piece shall be a strip of the flooring 50 mm wide and 225 mm long Six test piece shall be tested cut at random from the sample In the case of tiles

test piece from separate tiles shall be tested Three test piece shall be cut withtheir long dimensioss parallel to the grain of the flooring and three with these dimensioss at right angles to the grain Each test piece shall be conditioned at a temperature of 0+- 0 5 °C for at least 60 minute in air immediately prior to testing The mandrel shall be cooled to the test temperature The test peice shall be bent by hand over the mandrel with the wearing surface outward through an arc of 180 °C in approximately three seconds

METHOD OF MEASURING MOISTURE MOVEMENT

OBJECT:-

To evaluate the percentage moisture movement of PVC flexible flooring

APPARATUS:-

Shallow Tray - Approximately 300 *300 mm,50 mm In depth with a layer of glass balls Approximately 5 mm diameter in the bottom and filled to a depth of 40 mm with distrilled water

Steel Plate - 180 mm square and 13 mm thick for keeping the test speciman flat during measurement

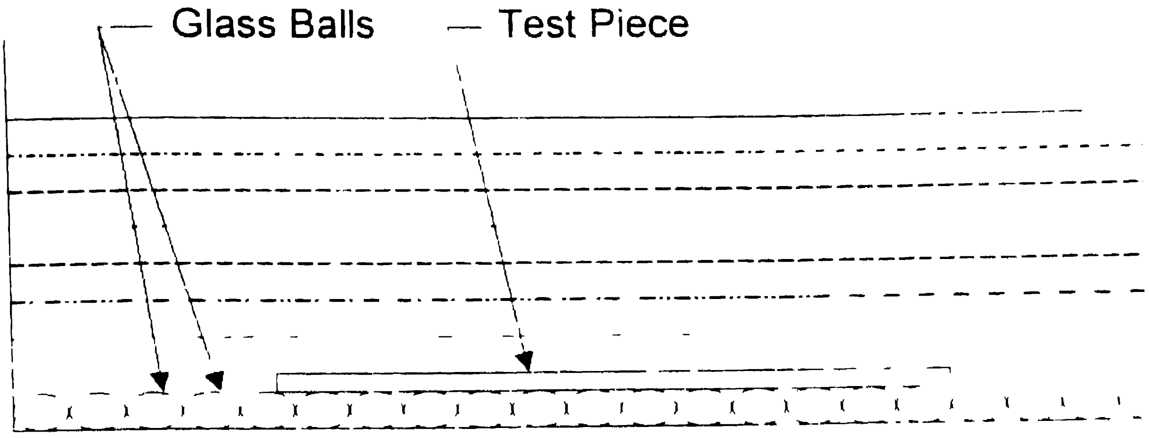
Travelling Microscope -

Desiccator - Containing dry silica gel

PROCEDURE:-

The test piece shall consist of a piece of the flooring not less than 225 mm^2 Two pieces shall be tested Test pieces shall be conditioned as given in 4 1 The test pieces shall marked for the dimensional stability best in accordance with 5 of IS .3464-1986 After maintaining at temperature of 27 +- 2 °C in the desiccator for

not less than 24 hours, the test piece shall be placed on a perfectly flat surface with the steel plate on top of it and the distence between each pair of marks to the nearest 01 mm shall be measured



Apparatus for Moisture Movement

The steel plate shall then be removed and the test shall then be placed on the layer of glass balls in the tray containing water and the distance between each pair of reference marks as previously described shall be remeasured

MEASURING HEAT AGEING AND EXUDATION

OBJECT:-

To determine the quality of PVC flexible flooring after ageing and to assess the flexibility

APPARATUS:-

A circulating air oven capable of maintaining a temperature of 70 +- 1 ^{0}C and a 25 mm diameter mandrel

PROCEDURE:-

The tets specimen shall be a strip of the flooring 50 mm wide and 225 mm long Three specimen cut from widely separated parts of the flooring shall be taken and shall be maintained at a temperature of 70 +- 1 ^{0}C in the circulating air oven for 15 days At the end of this time the speciman shall be removed from the oven, and then allowed to cool After a furthur period of 60 minutes at 27 +- 2 ^{0}C the speciman shall be examined for exudation by lightly rubbing the wearing surface with a clean white filter paper A greasy stain on the paper shows that exudation has occurred and constitutes a failure of the test

METHOD OF TEST FOR ELASTIC PRODUCT

OBJECT:-

To evaluate the product of tensile strength and elongation at break of PVC flexible flooring

APPARATUS:-

A constant rate of extension machine provided with a means of obtaining the force applied to the specimen and the corresponding extension of the specimen at the breaking point Under conditions of use the force at break shall be within one percent of true value

PROCEDURE:-

Each test piece shall be rectangular, 25 mm wide and at least 75 mm long Six pieces shall be cut from the sample three with their long sides as nearly as possible parallel to the calendering axis and three with their long sides at right

angles to this direction The samples shall be conditioned as given in The speciman shall then be mounted in the tensile resting machine in axial alignment with the direction of pull in such a way that the unclamped part of the speciman between the grips shall be 50 mm in length The speciman shall be loaded by separating the grips at such a speed that the rate of extension of the specimen is 100 percent per minute

METHOD OF TEST FOR PLASTIC FLOORING AND WALL TILES

Method of Test	Clause No.
(a) Dimensions	3
(b) Squareness	4
(c) Dimensional stability	5
(d) Colour fastness to daylight	6
(e) Volatile matter	7
(f) Curling	8
(g) Indentation	9
(h) Residual indentation	10
(i) Resistance to various substance	11
(j) Ply adhension	12
(k) Deflection	13
(l) Impact	14
(m) Opacity	15
(n) Crack and crazing	16

(o) Resistance to heat deformation	17
(p) Water absorption	18
(q) Surface spread of flame	19
(r) Absorption resistance	20

MEASUREMENT OF LENGTH AND WIDTH OF TILES

APPARATUS:-

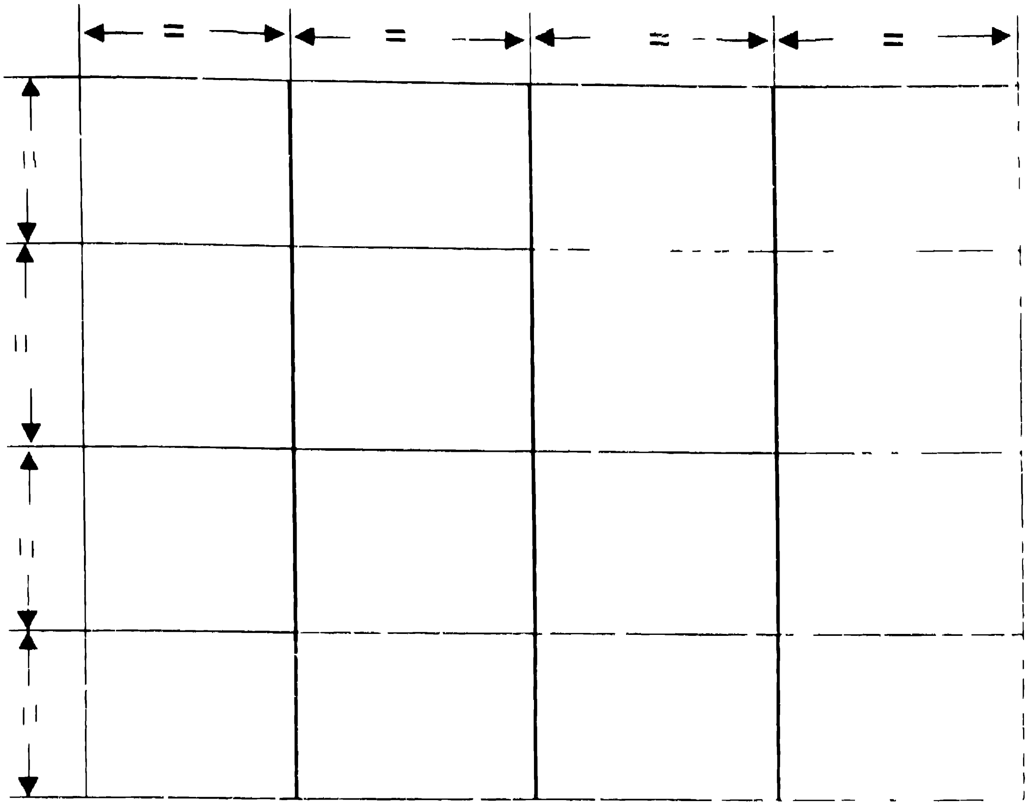
Atravelling microscope or any instrument capable of measurong to an accuracy of .01 mm

PROCEDURE:-

Immediately after conditioning as given, each tile shall be measured for length and width at the three quarter points in each direction

REPORT:-

The average of the three measurement in each direction shall be reported as the length or width of the tile in that direction



MEASUREMENT OF LENGTH AND WIDTH OF TILE

MEASUREMENT OF WIDTH OF SHEETS OR ROLLS

APPARATUS:-

Immediately after conditioning as given the sheet or roll shall be laid on a flat surface so as to fully expose the width without distortion The width of the speciman shall be measured in at least three places spaced equally along its length During measurement the tap shall be placed as nearly as possible at right angle to the edge of the sheet or roll

REPORT:-

The average of the reading shall be reported

SQUARENESS

OBJECT:-

To check the squareness of PVC asbestos floors tiles flexible PVC floor tiles and polystyrene wall tiles

APPARATUS:-

An L- shaped metal jig comprising two arms each of length greater than the side of the tile to be tested and of apprximately some thickness set in the shape of a true right angle on a metal base plate The plate shall be perfectly flat and free from surface defects

A set of feeler gauges or travelling microscope capable of measuring to 01 mm

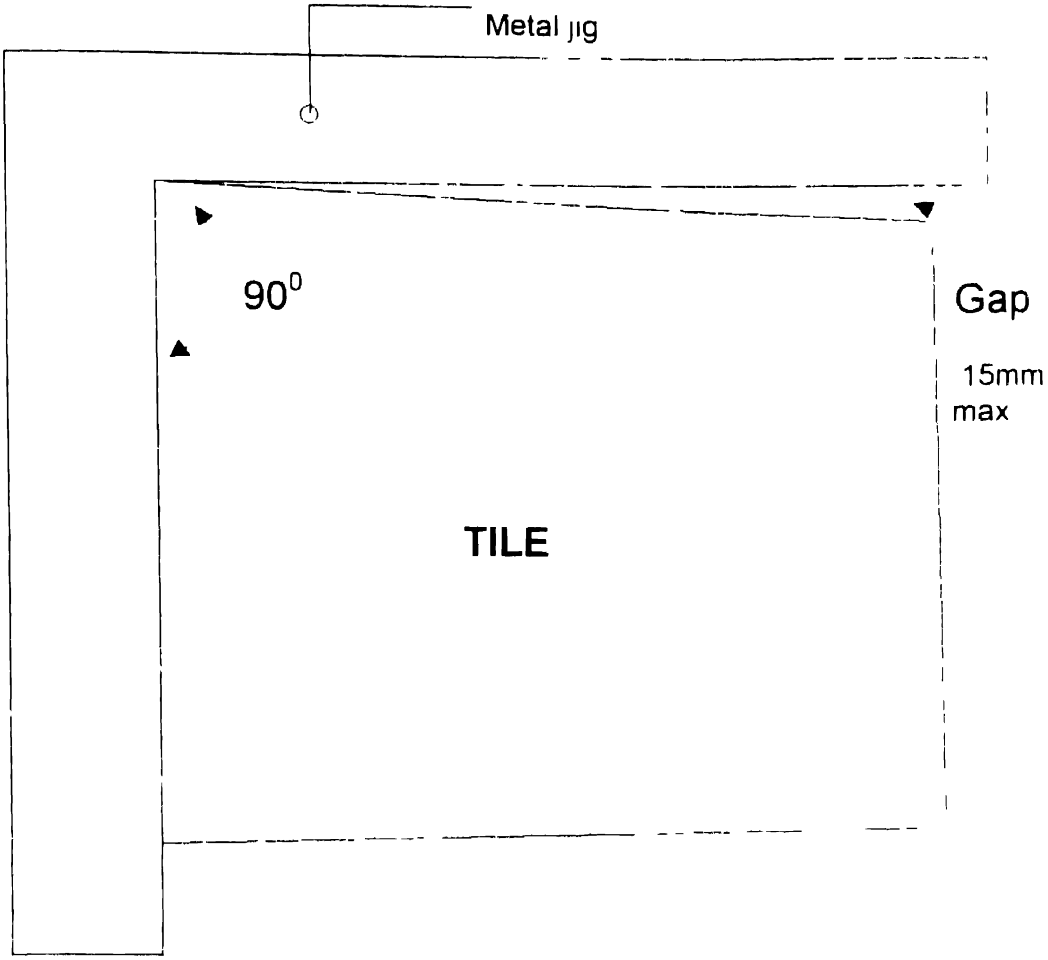
PROCEDURE:-

Immediately after conditioning as given, the tile shall be placed

Against the jig, each corner in turn being inserted into the right angle and one side of the tile held against one side of jig with light pressure Any gap between the sides of the tile and the metal arms shall be measured with the feeler gauge on microscope

REPORT:-

The gap measured shall be reported

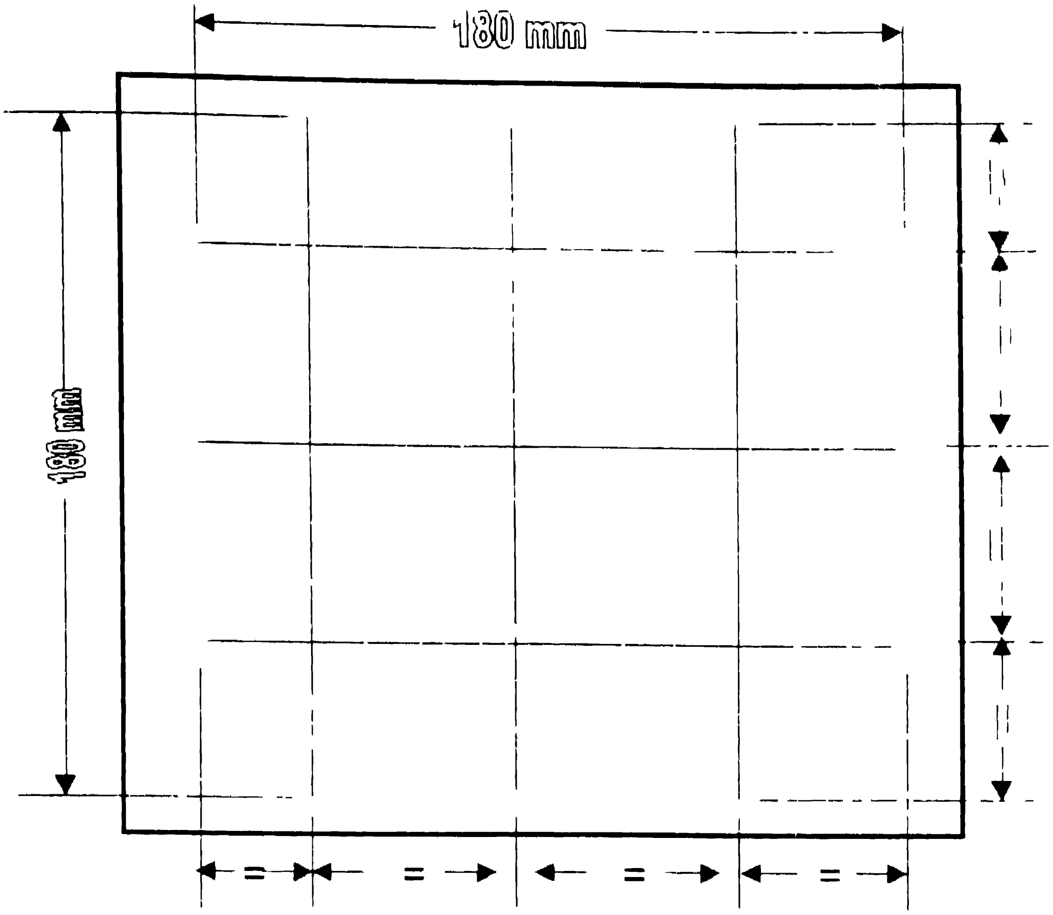


Method of checking Squareness of tile

DIMENSIONAL STABILITY

OBJECT:-

To determine the dimensional stability of PVC flixible flooring and PVC asbestos floor tiles



Reference marks on test specimen

APPARATUS:-

A circulated air oven having thermostatic control that will maintain a temperature of 80 +- 2 ^{0}C equipped with horizontal rigid metal plates or wired shelve for supporting the test piece The shelves shall be at least 25 mm larger than the test piece in each direction

A travelling microscope or suitable scale capable of measuring to an accuracy of 01 mm

A steel plate 180 *180 mm and 12 5 mm thick for keeping the test piece flat during measurement

TEST SPECIMAN:-

Test speciman shall not be less than 200* 200 mm Three sets of equally spaced reference marks shall be marked along each linear dimensions of the surface of the test speciman the mark in each set being 180 mm apart Two test speciman shall be tested

PROCEDURE:-

Immediately after conditioning as given the test speciman shall be placed on a perfectly flat surface with the 12 5 mm thick steel plate on top of it and the distance between each pair of marks shall be measured to the nearest 01 mm The steel plate shall then be removed and test speciman shall be placed horizontally on one of the shelves of the oven, with its wearing surface upward and maintained at a temperature of 80 +- 2 ^{0}C for six hours

The test piece shall then be removed from the oven allowed to cool to room temperature and then shall again be conditioned as given The distance between each pair of reference marks shall then be measured

COLOUR FASTNESS TO DAYLIGHT

OBJECT:-

To determine the colour fastness to daylight of flexible PVC flooring PVC asbestos floor tiles and polystyrene wall tiles

VOLATILE MATTER

OBJECT:-

To determine the volatile matter contained in PVC asbestos floor tiles

APPARATUS:-

A circulating air oven having thermostatic control that will maintain a temperature of 100 +- 2 ^{0}C

TEST SPECIMAN:-

Test pieces each measuring 200 * 50 mm shall be cut from tile samples

PEOCEDURE:-

The test piece shall be weighed individually to the nearest 01 g and then placed in the oven and maintianed at a temperature of 100 +- 2 ^{0}C for 6 hours At the end of this time they shall be removed allowed to cool in air to 27 +- 2 ^{0}C and reweighed

REPORT:-

The loss in mass shall be expressed as a percentage of the original mass and the average value calculated to the nearest 1 percentage shall be recorded

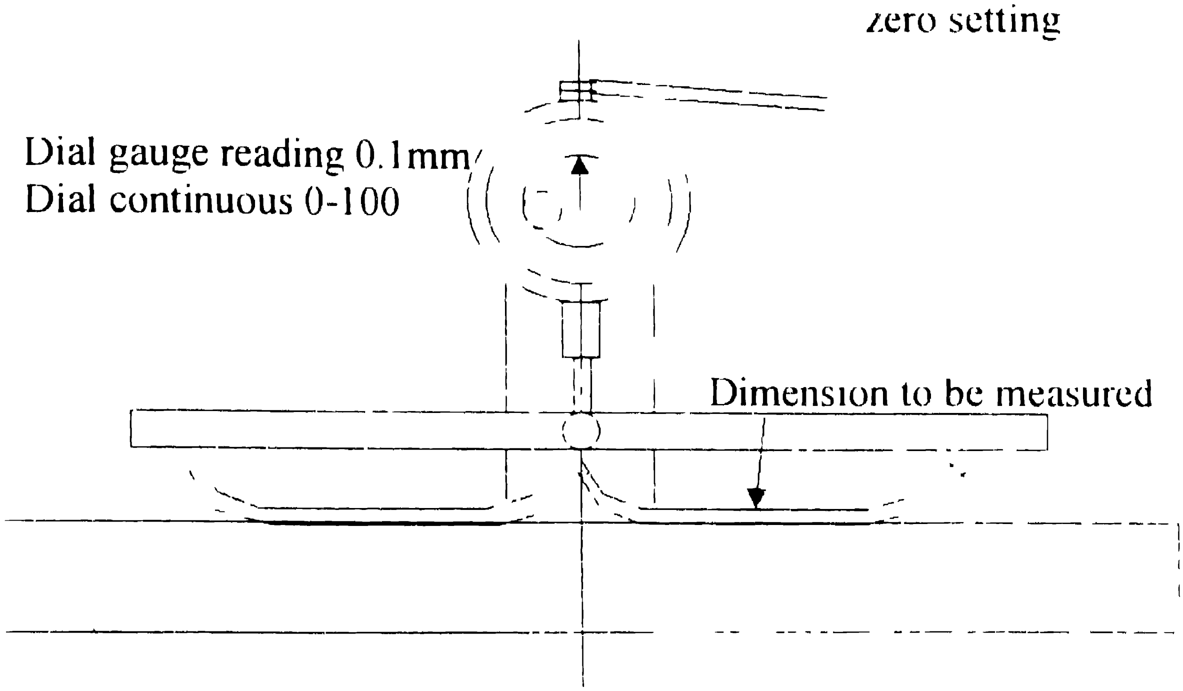
CURLING

OBJECT:-

To determine the amount of curl in flexible PVC flooring and PVC asbestos floor tiles

APPARATUS:-

A curl gauge of sufficient length to span the diagonal of the specimen and equipped with a dial guage graduated at 0.1mm intervals located so as to measure the curl at the centre of the Speciman



Speciman and equipped with a dial gauge at .1 mm intervals, suitable

Typical apparatus for curling test (A)

TEST SPECIMAN:-

Test pieces each measuring 150 * 150 mm shall be flat enough not to rock when either face is placed on a plane surface The gap between the tile surface

and a light straight edge placed on each pair of diagonally opposite corner shall not exceed 1 mm two test speciman shall be tested

PROCEDURE:-

The slab shall be placed in the waterbath so that the water level is approximately 3 mm below that the slab surface The wick material shall be so arranged that it covers the slab surface and extends in to the water on all 4 sides of slab

The test piece shall then be placed with its wearing face upwards on the wick material shall be allowed to remain there for a period for 72 hours during which the temperature of water shall be maintained at 27 +- 2 ^{0}C At the beginning and end of this period the gap between the test piece surface and a light straight edge placed on each pair of diagonally opposite corners shall be determined to the nearest 1 mm

REPORT:-

The average of the amount of the curling obtained for each test piece shallbe reported as the amount of curling

INDENTATION

OBJECT:-

To determine the amount of indentation obtained at 27 +- 2 ^{0}C and 46 +- 2 ^{0}C for PVC asbestos floor tiles

INDENTATION AT 27 +- 2 ^{0}C

APPARATUS:-

Indentation test:- Consisting essentially of a rod with a hemispherical end of 6.35 mm diameter through which a load of 9 N and a total load of 136 N can be applied to the surface of the test piece and a dial gauge from which the amount of indentation can be read.

Flat rigid Plate:- At least 6.35 mm thick for supporting the test piece during the test.

Water bath:- That can maintain the required temperature

Test speciman:- The test pieces shall be whole size tiles

PROCEDURE:-

The test piece together with the indenting rod shall be maintained at a temperature of 27 +- 2 ^{0}C for at least 60 minute in air prior to testing The test piece shall then be placed on the horizontal flat rigid plate with the base od indentation tester resting on its surface. The hemispherical end of the indenting rod shall be applied to the surface of the test piece under a load of 9N and the reading of the dial gauge noted An additional load of 127 N shall then be applied to the indenting rod within 5 second and the reading of the dial gauge 1 minute and 10 minute after the application of this load shall be noted.

REPORT:-

Reading shall be taken at three scattered point on the test piece and the average shall be reported

INDENTATION AT 46 +- 2 ^{0}C

APPARATUS:-

Indentation test - Consisting essentially of a rod with a hemispherical end of 6 35 mm diameter through which a load of 9 N and a total load of 136 N can be applied to the surface of the test piece and a dial gauge from which the amount of indentation can be read

Flat rigid Plate - At least 6 35 mm thick for supporting the test piece during the test

Water bath - That can maintain the required temperature

Test speciman - The test pieces shall be whole size tiles

PROCEDURE:-

The procedure shall be the same as above except that the test piece and the indenting rod shall be maintained in the water bath at a temperature of 46 +- 2 ^{0}C for at least 15 minute prior to testing and the additional load of 127 N shall be applied to the indenting rod within 5 seconds, and reading of the dial guage shall be taken 50 seconds after the application of this load

REPORT:-

Readings shall be taken at three scattered points on the test piece and the average shall be reported

RESIDUAL INDENTATION

OBJECT:-

To determine the amount of residual indentation obtained at 27 +- 2 ^{0}C on PVC flexible flooring and PVC asbestos floor tiles

APPARATUS:-

Indentation Tester - Consisting essentially of a smooth steel plate for supporting the test piece and an indenting tool in the form of a cylindrical steel rod of 4 5 mm diameter at the final contact point through which a load of 360 N can be applied The edge of the indenting tool shall have a radius of 1 5 mm

Dial guage capable of exerting a pressure of 14 +- 035 N /mm^2 on a foot not more than 4 mm in diameter

TEST SPECIMEN:-

Four test pieces each measuring 50 * 50 mm shall be cut from different tiles or from widely separated parts of the speciman in case of roll or sheet

PROCEDURE:-

The thickness of the test piece shall be measured to an accuracy of 01 mm It shall be then placed on the steel plate of the indentor The indentator shall be allowed to rest on the wearing surfaceand the reading on the ddial guagenoted A load of 360 N shall be applied to the wearing surface for a period of 10 minutes by means of the indenting tool The pressure shall be applied at the same point at which the thickness was measured At the end of 10 minutes the load shall be

completely removedfrom the test piece and the test piece shall be allowedto stand at a temperature of 27 +- 2 ^{0}C for a period of 60 minute At the end of this time the depth of indentation shall be measured at the point of indentation to the nearest 01 mm

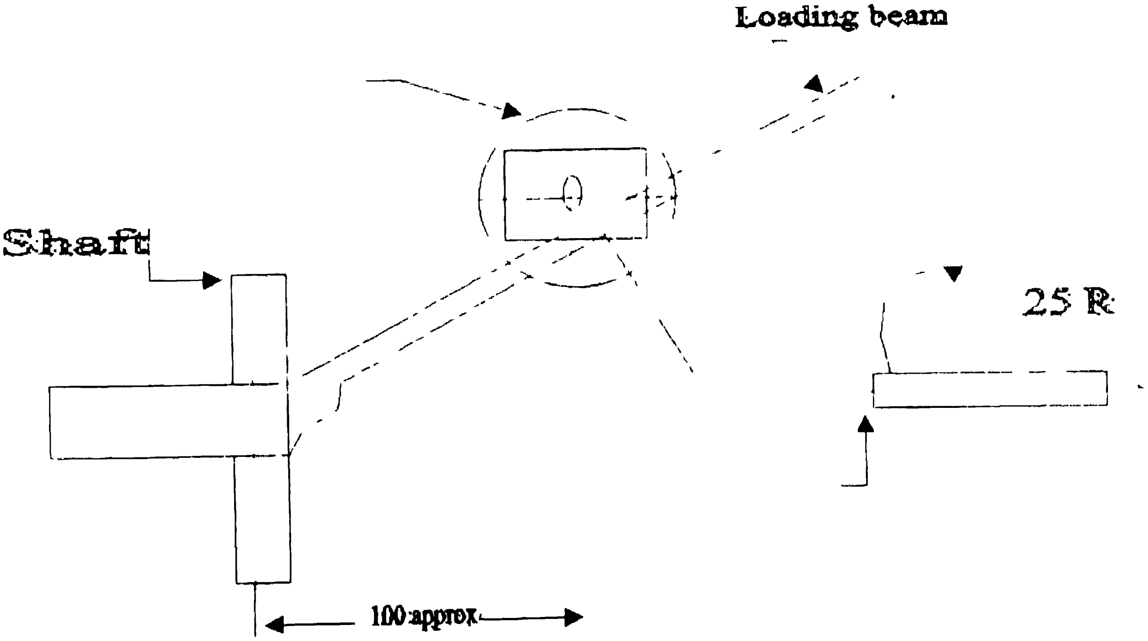
REPORT:-

The average of the values for all the test piece shall be reported

RESISTANCE TO VARIOUS SUBSTANCES

APPARATUS:-

A suitable tester consisting of a horizontal table rotatable about a vertical axis and a loading beam which rotates in a vertical plane about a horizontal shaft



Tester for Resistance to various substances

The table is 100 mm in diameter and may be rotated by hand The test speciman is fixed securely to it by clamps The loading beam pivot about 100 mm from the axis of the rotating table can be adjusted vertically to allow the loading beam to remain horizontal whatever thickness of speciman is used The loading beam is arranged to apply a load of 5 N to a scratch tool of tungesten carbine 4 8 mm wide and ground to a radius of 25 mm held at a shear angle of 22^0 to the direction of the motion of the speciman and its leading edge at an angle of 450 to the speciman

TEST REAGENTS

Isopropyl Alcohol

Light Mineral Oil

Cotton Seed Oil

To persent aqueous solution of sodium hydroxide

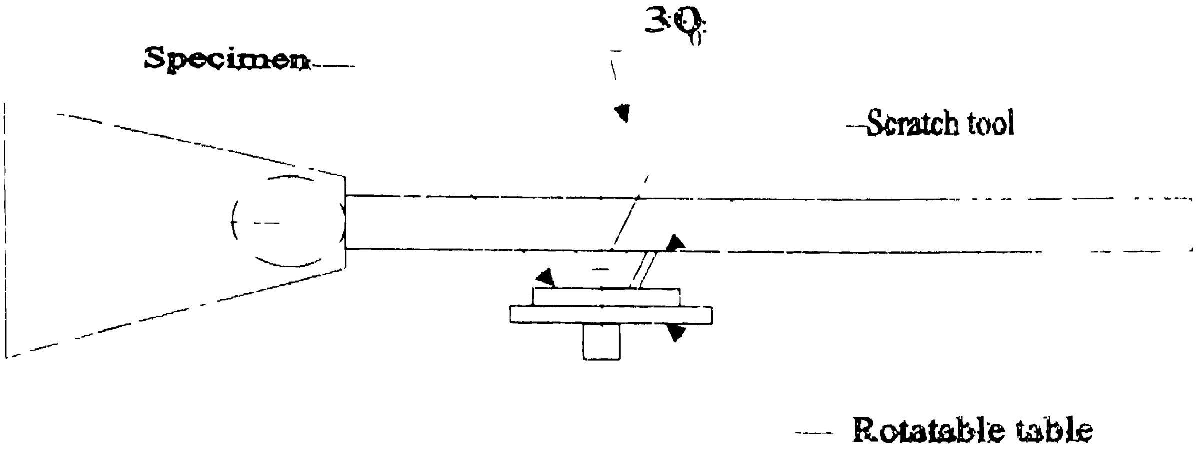
TEST SPECIMEN:-

Three sets of five test piece each measuring 50 * 75 mm shall be cut from the tiles or from the specimen sheets or rolls

Preparation of the test specimen-

One test piece from each set shall be set aside for checking the sharpness f the scratch tool and the remainder shall be immersed individually in each of the above reagents for a period of 46 +- ¼ hoursve reagents for a period of 46 +- ¼ hours The test piece shall be immersed temperature of 27 +- 2 ^{0}C and shall be maintained at that temperature for the duration of the test If more than one test

piece is immersed in a single container it shall be seperated by a distance of approximately 3 mm from other test piece to ensure that each test piece is fully immersed in the medium



Tester for Resistance to various substances

The test pieces in each container shall be limited to those cut from one tile or from one sheet of flooring At the end of the immersion period the test piece shall be removed from the immersion medium blotted with a soft absorbent tissue and immediately examined visually from any colour changes and then subjected to scratch test

Preparation of scratch tool-

The scratch tool shall produce a scratch of 1 1 to 1 4 mm in width when unimmersed test pieces are tested in accordance with procedure If it produces the required width by drawing it across unimmersed test pieces Care shall be taken in handling and storing the tool to ensure that the cutting edge is not damaged

PROCEDURE FOR MAKING THE SCRATCH

The test piece shall be clamped firmly on the table by means of the test piece holder The loading beam with the scratch tool in posotion shall be gently lowered until the scratch tool rests on the test piece under a total load of 5 N The tool shall be at least 6 35 mm from any edge of the test piece at all times

The table shall be rotated slowely and steadily by hand in a counter clockwise direction until a scratch of 25 mm in length is obtained The loading and the width of the scratch shall be measured to the nearest 1 mm at three equally spaced places The order of testing shall be firstly an unimmeresed test piece and then those that have been immersed in the order as given in fig The order of testing shall be repeated until the required number of test pieces have been tested

REPORT:-

Scratch Resistance:-

The average of the three sets of values shall be recorded to the nearest 01 mm as the scratch resistance of the test piece to that substance

Colour:-

An unimmersed test piece and an immersed one from each set shall be placed on a plane surface beside each other and examined in a bright or north light for any change in colour immersed test piece

PLY ADHESION

OBJECT:-

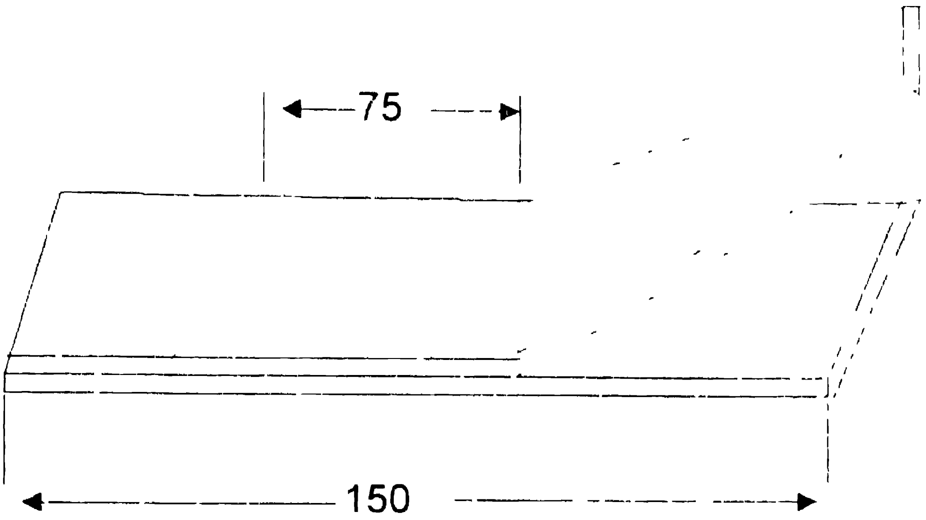
To determine the ply adhesion of PVC flexible flooring

APPARATUS:-

A tensile testing machine having the rate of movement of 280 +- 25 mm per minute of the driven grip measured before each series of tests with the machine at zero load The machine shall be capable of reading to 0 +- 2 N

TEST REAGENT:-

Ethyl acetate of pure grade conforming to IS 229-1972



TEST SPECIMEN:-

Six test piece each measuring 150 * 50 mm shall be cut from the specimens having the long axis parallel to the grain and equal number at right angle to the grain

PROCEDURE:-

The width of each test piece shall be measured at the three quarter point and the average shall be regarded as the width of the test piece Three parallel lines shall be marked on the surface of each test piece Each test piece shall then be supported vertically for a period of 45 minute in ethyl acetate to a depth of not more than 20 mm After immersion that part of the laminate which has been in the solvent shall be separated by hand but without undue force The test piece shall then be allowed to dry at a temperature of 27 +- 2 ^{0}C until all the solvent has evaporated and in any case for not less than 90 minute Each test piece shall then be separated in the tensile testing machine the load for separation of 75mm marked section of the test piece shall be noted and the average of six reading recorded

REPORT:-

The ply adhesion for each test piece shall be calculated in kN/m as follows

$$\text{Ply adhesion} = \frac{\text{Average load of separation (N)}}{\text{Width of test piece (mm)}}$$

The lowest value shall be reported

RESISTANCE TO HEAT DEFORMATION

OBJECT:-

To determine the amount of deformation to heat on polystyrene wall tiles

TEST SPECIMEN:-

The test pieces shall be whole size tiles

PROCEDURE:-

The test piece shall be kept vertically without touching each other in a wire basket, and immersed for 10 minutes in 5 liters of water maintained at a temperature of 70 +- 2 ^{0}C

The basket with the test piece shall then be placed in air at a temperature of 27 +- 2 ^{0}C for at least 10 minutes

The feces of the tiles shall be examined for changes in appearance The deformation of the edges from a straight line shall be assessed by using a straight edge and feeler gauge

REPORT:-

Visible changes in appearance and the deformation on the edges of the tiles from a straight line shall be examined and the average reported

WATER ABSORPTION

OBJECT:-

To determine the percentage water absorption of polyster wall tiles

TEST SPECIMEN:-

Test pieces measuring 50 * 50 mm shall be cut out from different tiles

PROCEDURE:-

The hessian backing of the test piece shall be removed and weighed The test piece shall than be immersed completely in distilled water maintained at a

temperature of 27 +- 2 ^{0}C for 24 hours Immediately after removel from water the surfaces of the test piece shall be wiped dry with filler paper and reweighed

The water absorption of the test piece shall be calculate as follows

Persentage water absorption= $\frac{M2-M1}{M1} * 100$

Where= (g)

M2= mass of the test piece after immersion and

M1= mass (g) of the piece before immersion

REPORT:-

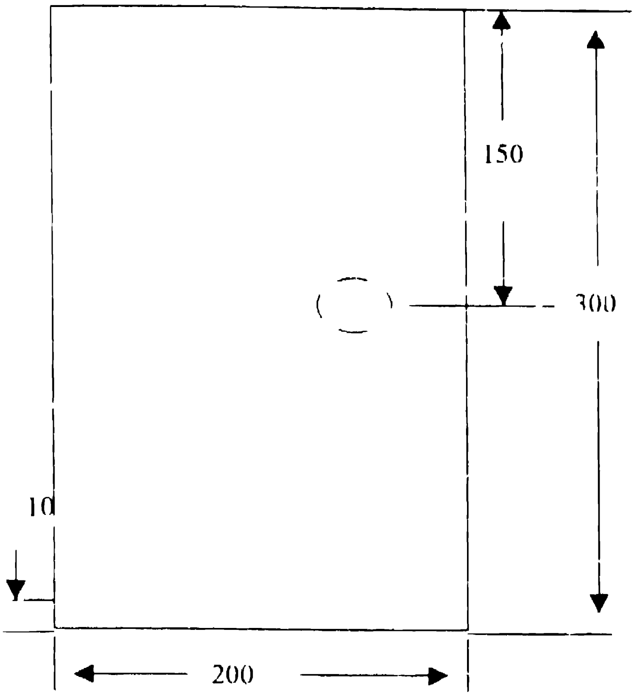
The average of all the determination shall be reported

SURFACE SPREAD OF FLAME

OBJECT:-

To determine the area of char of the polystyrene wall tiles

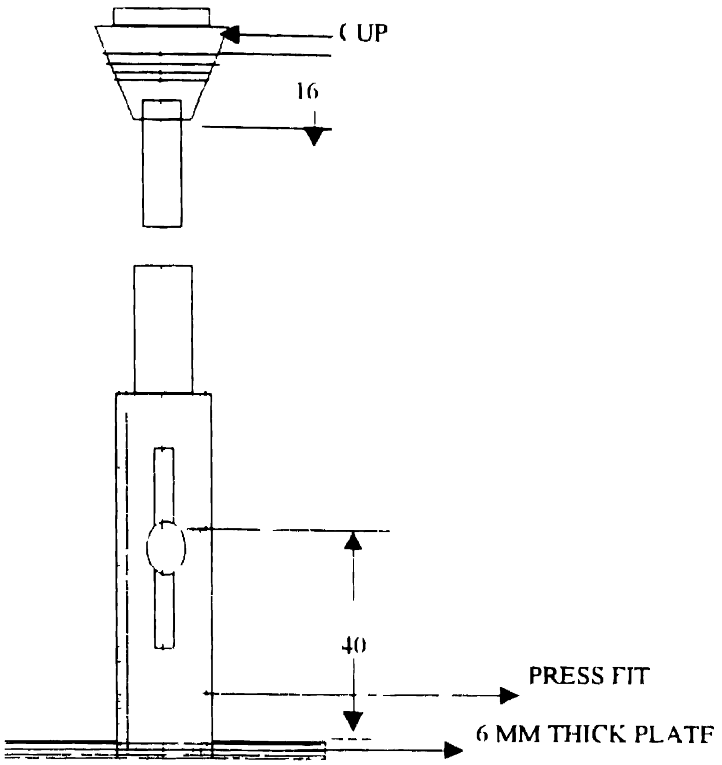
APPARATUS AND MATERIALS:-



Apparatus for testing surface spread of flame

Specimen Support:-

Suitable means shall be provided for supporting the specimen during the test at an angle of 45^0 with the upper and lower edges of the plane of support being horizontal This may be accomplished by resting the specimen on four points but it is necessary whatever method of support be employed that (a) the central portion of the specimen shall not be shielde from the flame (b) the supports shall not prevent access of air from combusion and (c) the apparatus shall be such that the progress of the test can be observed A suitable apparatus is shown



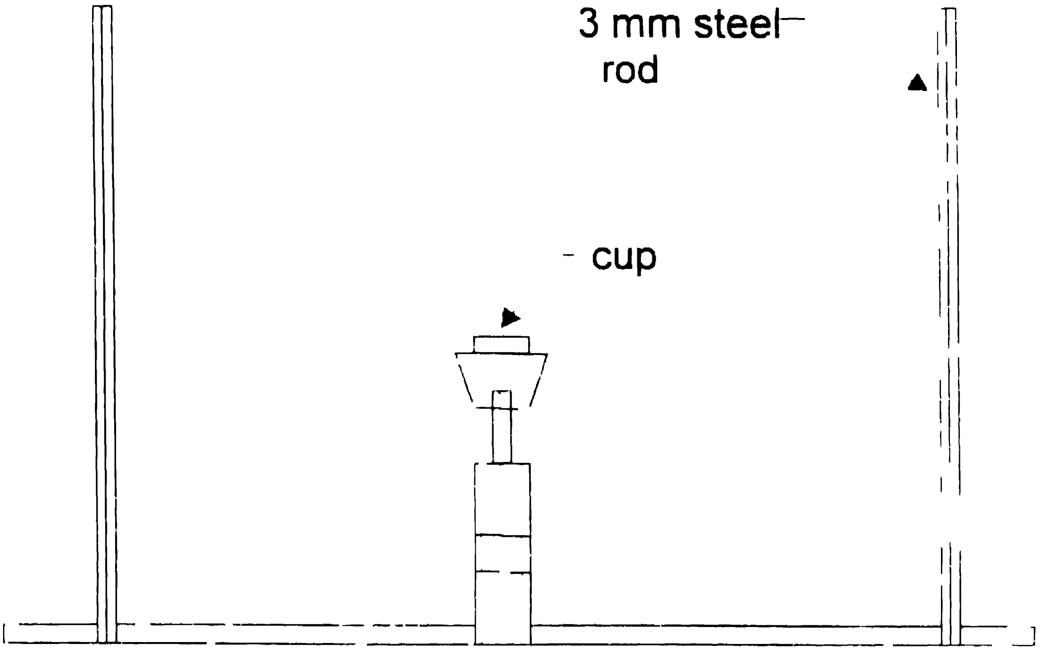
Apparatus for testing surface spread of flame

TEST SPECIMEN:-

The test piece shall be whole size tiles

PROCEDURE:-

Place the specimen on the test apparatus Place 1 cc of absolute ethyl alochol in the cup from a suitiable pipette or other means and ignite by a small gas or oil jet or other suitable source of heat which shall be removed as soon as the alcohol is lighted The cup shall be at room temperature before each test The test shall be made in a draft free room or enclosure with a subdued light



Apparatus for testing surface spread of flame

One minute after the fule has been exhaused extinguished any flame and glow on the specimen and determine the area of char If the duration of flaming is less than one minute extinguish any smouldering and measure the area of char Determine the area of char by cutting slots approximately along the major and minor axis of the elliptical char area Determine the length of these axis by taking the terminal of each line as that point where a definite charring or decomposition of the flooring material has taken place

PRODUCT RANGE & APPLICATIONS OF FLOORINGS :

The flooring manufactured by Premier ployfilm applies to interior flooring intended mainly for use in traffic and living areas in residential premises offices hostel educational institutes and hospitals and buildings similar to one of these five categories The technical flooring produced are intended to use in computer rooms or the rooms having highly sophisticated equipments and ordinance factories

VINYL FLOORINGS

Flexible flooring in which the layers apart from the integral backing are produced from a mixture of PVC Resign, Plasticizer, stabilisers and other additives and possibly opacifying agents and fillers PPL's wide range of products offer the following

UNBACED FLOORINGS

(A) HOMOGENEOUS MULTILAYEER UNBACED FLOORINGS:

Material produced by laminating or pressing together sheets of the same composition and appearance (especially marbling density) which therefore shows no variation in performance when the thickness is reduced locally by abrasion Homogeneity of performance implies uniformity of resistance to abrasion throughout the thickness of the surface

PRODUCT : **Supreme**
THICKNESS : **2.0 M M**
CONFORMANCE : **IS –3462, BS 3261 : AS 2055**
DIN –16951 : ASTM-1066
APPLICATION : **Public and commercial offices Hospital**
Schools Railways Auditoriums etc.

(B) HETRIGENEDUS FLOORINGS :

Material produced by laminating, pressing sheets or layers of different compositions and/ of colours This is formed by the first layer of material which is homogenous in performance from the visible surface downwards

PRODUCT : **Supreme Popular**
THICKNESS : **2.0 M M**
CONFORMANCE : **IS –3462, BS 3261 Part II**
APPLICATION : **Auditoriums Educational Institutions.**

(C) TECHNICAL FLOORINGS :

The PPL range also includes special purpose floorings

(a) ANTISTAT FLOORING

The flooring capable to control the accumulation and dissipation of static charge Static charge which is generated by simply moving on the surface through friction of rubbing and separation of shoe sole to floor surface is dissipate by antistatic flooring It allows free movement of individuals and protects the entire workstations

CONFORMANCE	**IS –3462, AND BS2050**
THICKNESS	**2.0 M M**
APPLICATION	**Computer rooms, IC units in Hospital Radar Stations, Telephone Industries etc.**

(I) HOSPITALS

Antistatic flooring helps to prevent fire or explosion where flammable anaesthetics are used, controls in voluntary personnel flammable anaesthetics are used controls in voluntary personnel movement caused by electrostatic charge and helps to prevent hazardous static discharge directly in to patients This also protects sensitive processing installations

(II) COMPUTER AND ELECTRONIC EQUIVALENT INSTALLATIONS:

Antistatic flooring controls static discharges into computer terminals or other electronic equipments thus providing and shield to internal circuitry loss of

computer memory or other malfunctions It protects large data processing facilities, process control equiptments, communication installations and other sensitive instruments

(b) Conductive Flooring :

Capable to fulfil its defined function of dissipating electrostatic charges and conducting electricity during the whole of its life

CONFORMANCE : IS –3462, AND BS2050

THICKNESS : 2.0 M M

APPLICATION : Suitable for ordinance factories. This flooring helps to prevent explosions during explosive handling in ordinance factories.

(c) ANTI ACID FLOORING :

This is flooring offers resistance to corrosive chemicals and hence it is highly recommended for chemical labs, factories and metal tank linings used for storing chemicals

THICKNESS : 2.0 M M

CONFORMANCE : IS –3462-FOR MECHANICAL BS-3261- PROPPERTIES.

APPLICATION : Chemical factories, Tank lining for storing chemicals etc.

(c) ANTISKID/ GRIPPER FLOORING :

It is a corrugated flooring with a floated top layer for skid proof quality Although, it is unbacked flooring but a woolen felt backing may also be provided

THICKNESS : **1.5 M M**

CONFORMANCE : **IS –3462, BS 3261 PART-I**

APPLICATION : **It is highly recommended for automobiles mats, airport, ramps conveyors, railway pantry, car bus coaches etc.**

BACKED OR SUPPORTED FLOORING

These are the laminated PVC flooring which are supported by a backing A general term used for a layer or combination of layers is -

- Located on the back of a material
- Of a texture differing considerably from that of the surface layer
- Acting at leat partially as reinforcement

In Vinyl floorings the reinforcement acts as a flexible backing The backing used in the Premier Polyfilm is Jute felt, Polyester felt and Jute Mat or Hessian

(A) JUTE BACKED PVC FLOORING :

It is a printed flooring with the combination of Vinyl layers and jute felt acts as a backing

THICKNESS : 4.0 MM x 3.0 MM

WIDTH : 1.32 Mtrs, 1.5 Mtrs & 1.83 Mtrs.

CONFORMANCE : DIN-16952 & EN UEAtc MOAT No.36

APPLICATIONS : Usually used in cold areas i.e. where temp. Always remain less than 5 degree centigrade.

(B) POLYSTER BACKED PVC FLOORING :

A printed flooring consisting of a combination of Vinyl layers applied directly to a backing of non-town polyester felt visible on the back side

THICKNESS : 2.5 MM

WIDTH : 1.5 Mtrs,

CONFORMANCE : EN UEAtc MOAT No.36

APPLICATIONS : Usually used in cold areas i.e. where the temp. remain below 5 degree centigrade.

(C) JUTE MAT OR HESSAIN BACKED FLOORING :

A special purpose flooring which has an advantage of using in both cold & normal temp areas This is also a printed flooring

THICKNESS : 1.4 MM x 1.6 MM

WIDTH : 1.5 Mtrs & 1.83 Mtrs.

CONFORMANCE :

APPLICATIONS : Usually used in cold areas i.e. where temp. Always remain less than 5 degree centigrade.

STANDARD SPECIFICATION FOR FLOURINGS

S. NO.	CHARACTERISTICS	VALUES
1	**Thickness**	Mean thickness + 0 13 MM
2	Width	Specified + 6MM (Max)
3	Squarness	0 15MM (Max)
4	**Dimensional Stability**	0 4% (Max)
5	Duerling	0 75MM (Max)
6	**Ball Indentation at**	
	27+2 C	0 65MM (Max)
	After 1 Min	0 85MM (Max)
	After 10 Min	
	At 46 + 2 C	1 05 MM
	After 50 Sec	
7	Residual Indentation	0 10MM (Max)
8	Ply Adhesion	1 05 KN/M (Min)
9	Elastic Product	2MJ/M3 (Min)
10	Moisture Movement	0 4% (Max)

GENERAL DIRECTIVES RELATING TO QUALITY

1 SLIPPERINESS:

Although it is difficult to establish a limit for the characteristic of this type, but it is suggested that coefficient of friction between the foot and the flooring is normal and does not allow any type of slipperiness

PERFORMANCE IN FIRE:

In the event of accidental or in case of fire the flooring does not

- Ignite easily
- Spread the flame

3 MEAR

A satisfactory flooring in respect of traffic, flatness, levelness and easy to laid and install

4 NORMAL HYGIENE:

It is capable to carry out disinfection, taking into consideration the cleaning and maintenance method

5 ACOUSTIC COMFORT:

The flooring provides a negligible partial or significant contribution to insulation impact sound

6 INTRINSIC DURABILITY:

It is characterised by the term resistance to aging i e the flooring once laid can be used four years

7 MAINTENANCE:

The properties of the flooring surface are able to maintain close to their original state by fairly simple methods

STANDARD CLEANING & STAIN REMOVAL OF PRODUCTS

1 White Cotton, in pad or cloth form

2 Brushes, hard & not likely to score & surface

3 Tepid water (35-40 degree Celsius), used on its own or with the addition of a product such as

- A synthetic detergent, for instance Sodium Alkyl Sulphate of the anionic type (Teepol),
- Soap (Sode or potesh & Vegetable oil based)
- Alkaline Wasino product (Washing soda or ammonia Solution based)

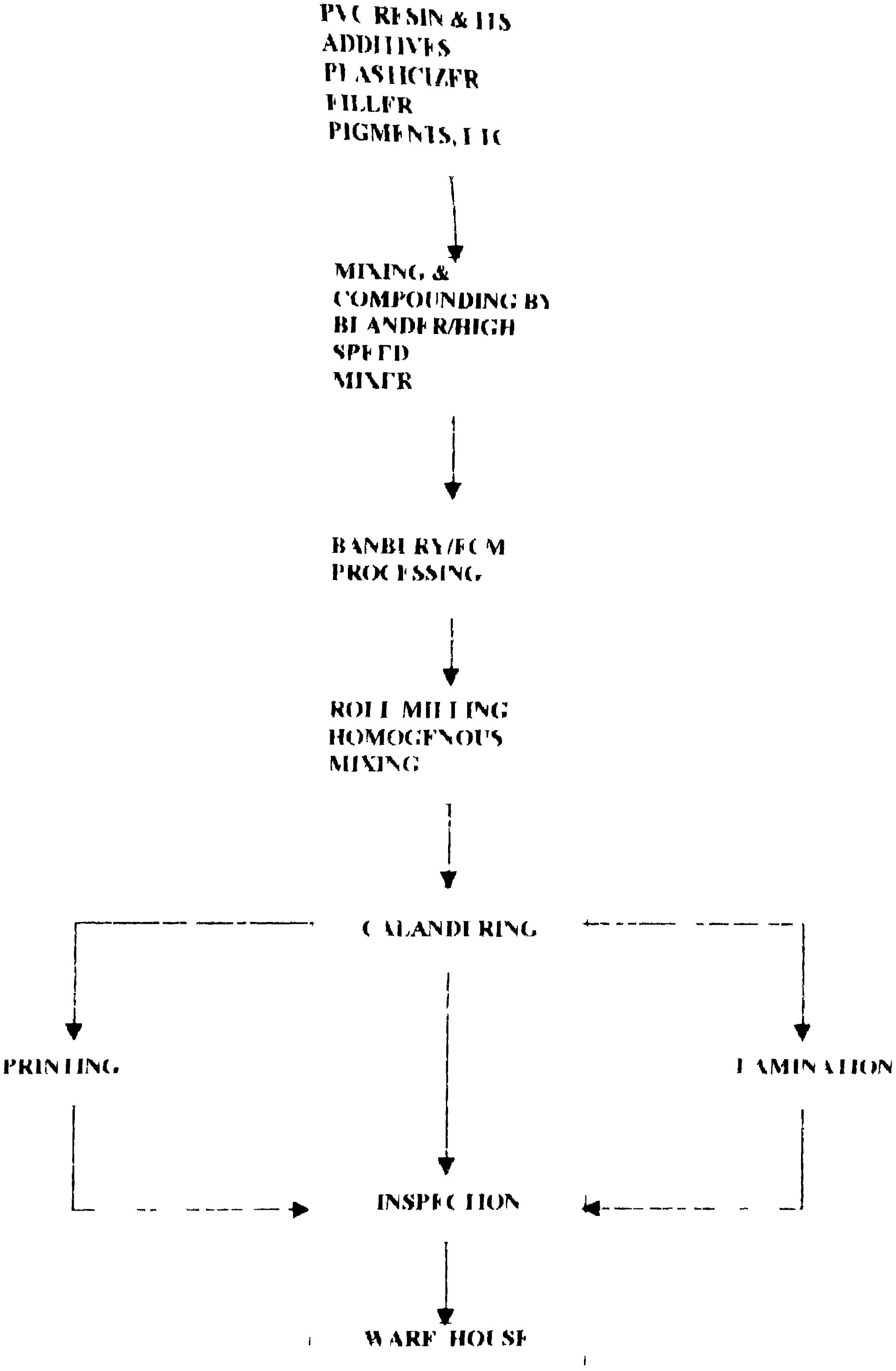
4 Hydrogen Peroxide, 30 Vols, used on its own or with the addition of 1% ammonia

5 Sodium Thiosulphate solution

6 Methylate spirit

7 Acetone

PROCESS FLOW CHART


PVC RESIN & ITS ADDITIVES PLASTICIZER FILLER PIGMENTS, ETC
MIXING & COMPOUNDING BY BLANDER/HIGH SPEED MIXER
BANBURY/FCM PROCESSING
ROLL MILLING HOMOGENOUS MIXING
CALANDERING
PRINTING
LAMINATION
INSPECTION
WARE HOUSE

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